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BURNER CONTROL APPARATUS

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FIG. 1

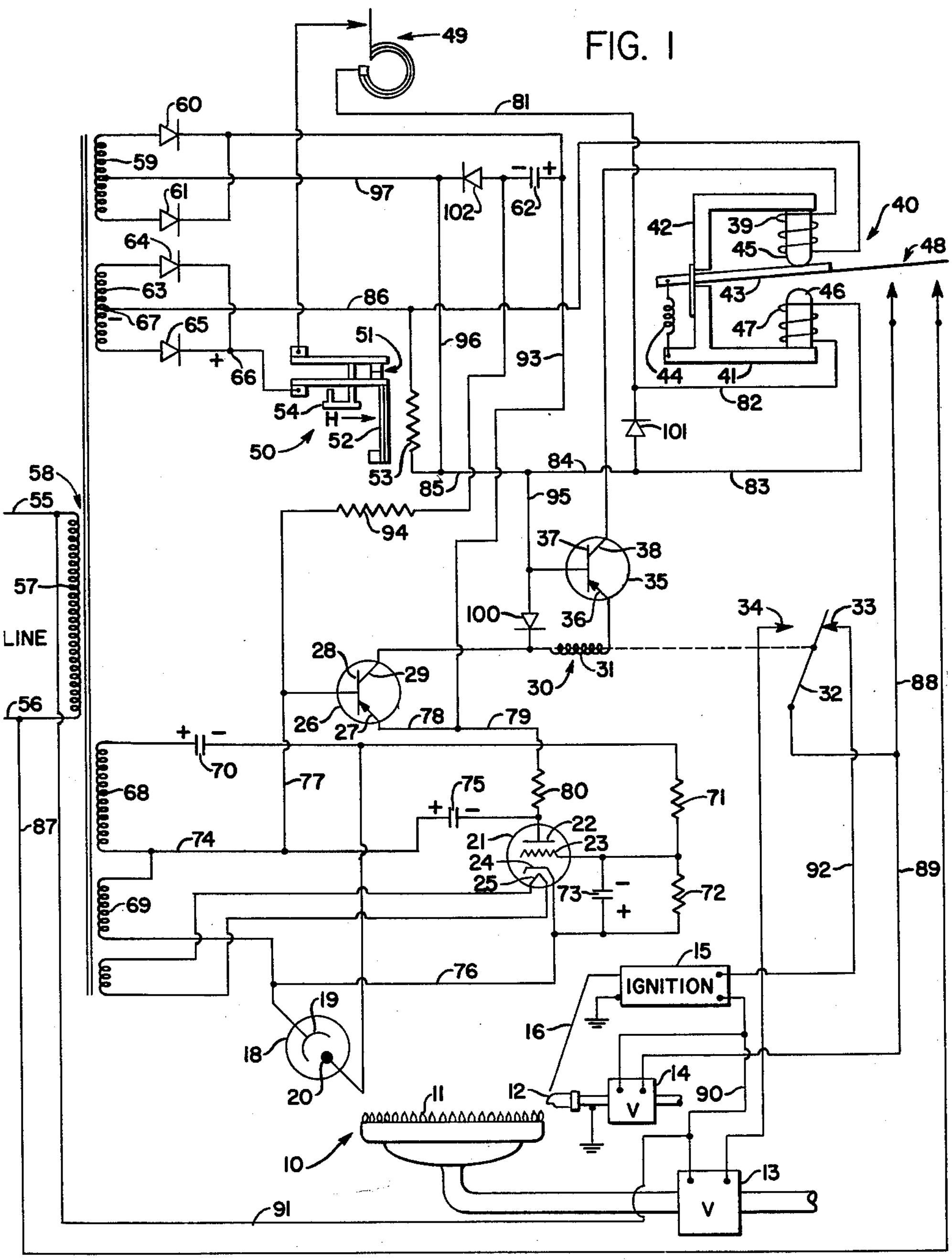

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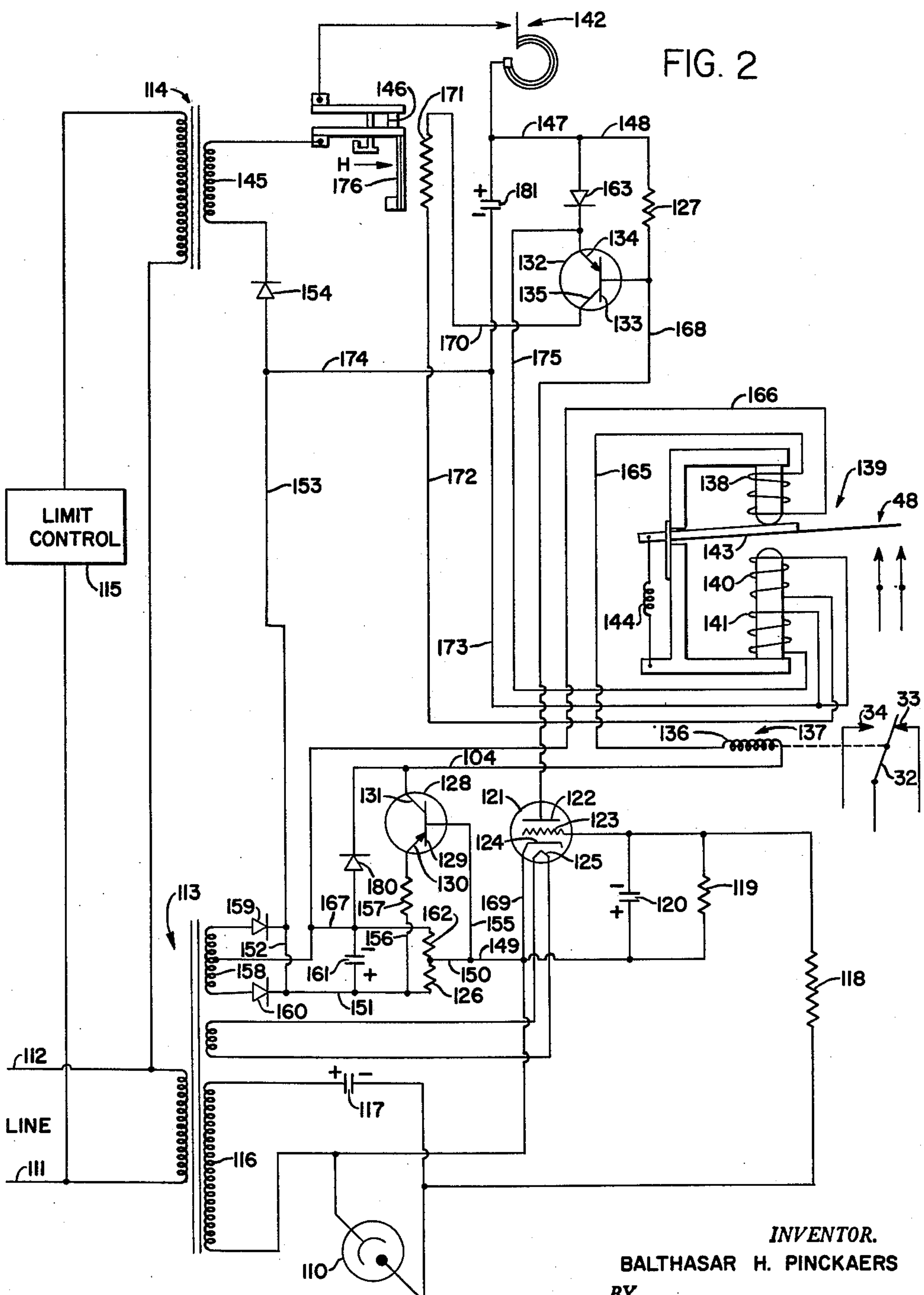
FIG. 2



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BURNER CONTROL APPARATUS
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This invention is concerned with an improved burner control apparatus and more particularly with an improved burner control apparatus utilizing a unique means of interlocking the operation of the main burner control relay and the flame detector relay.

Electronic flame detectors have received wide acceptance in the commercial market by virtue of the fact that this particular type of flame detector acts very quickly to sense the presence or absence of flame. In this type of a flame detector, it is a usual expedient to provide means such as a photocell or a flame rod which is positioned to view or be subjected to the presence or absence of combustion at the fuel burner unit. The output of such a means is connected to an electronic network, and the output of the electronic network is connected to control a flame relay to cause this relay to move from one state of energization to a second state when the presence of combustion is detected at the fuel burner unit.

The overall control of the fuel burner unit is achieved by either manual or by automatic control means, for example a thermostat, which is connected in circuit with a main burner control relay to energize this relay in the event that there is a need for operation of the fuel burner unit. However, in order to check proper operation of the flame detector at this time, interlock means are normally provided whereby the main burner control relay cannot be energized at this time unless the flame relay is in a condition indicative of the absence of flame at the fuel burner unit, it being remembered that the fuel burner unit is actually deenergized at this time. Furthermore, safety cutout means are provided to insure that the fuel burner unit will be deenergized in the event that an unsuccessful attempt is made to establish combustion thereat. This safety cutout means is controlled by the flame relay and is rendered inoperative to perform its cutout function in the event that the flame relay moves to its condition indicative of the presence of flame at the fuel burner unit.

The present invention provides the above described general functions in a new and unique manner which eliminates the necessity of providing switching contacts in the control circuit for the main burner control relay. Specifically, this function is achieved by utilizing a main control relay having a first and a second winding associated with a movable relay armature. The first winding is effective, when energized, to exert a force on the armature tending to cause the armature to move to a position wherein normally open switch means are moved to a closed condition. These switch means are adapted to be connected to a fuel burner unit to energize the same upon being moved to this closed position.

The main control relay is also provided with a second winding which is operatively associated with the armature when the armature is in its deenergized position and the second winding is effective to maintain the armature in this deenergized position and prevent closing of the normally open switch means if the second winding is energized at the time that the first winding is energized. In this manner, should the electronic flame detector fail in a manner so as to indicate that there is a flame present at the fuel burner unit when in fact the burner unit is deenergized, the thermostat cannot energize the burner unit since energization of the first relay winding is ineffective to move the armature to the energized position. As will be appreciated, such a construction eliminates the necessity of providing interlocking type switching contacts in the circuit of the main control relay.

Furthermore, the present invention provides the above described arrangement in combination with unique means for controlling the energization of the actuator of the safety cutout means. This is also done without the necessity of providing switching contacts, which experience has shown can become contaminated and provide faulty operation.

The present invention will be apparent to those skilled in the art upon reference to the following specification, claims, and drawings, of which:

FIGURE 1 is a schematic representation of a first embodiment of the present invention, and

FIGURE 2 is a schematic representation of a second embodiment of the present invention.

Referring to FIGURE 1, the reference numeral **10** designates generally a fuel burner unit having a main fuel burner **11** and a pilot burner **12**. The flow of fuel to the burners **11** and **12** is controlled by valves **13** and **14**, which valves are normally closed and adapted to open and admit fuel to their respective burners upon being energized. Reference numeral **15** designates ignition means in the form of an ignition transformer. This ignition means is connected to an ignition electrode **16** disposed in cooperating relationship with burner **12** to provide ignition spark.

The presence or absence of combustion at the fuel burner unit **10** is monitored by flame detecting means including a photoemissive cell or flame sensing means **18** having a cathode **19** and an anode **20** disposed in viewing relationship to the fuel burner unit.

As will be described more completely, photocell **18** is connected in controlling relationship to a low voltage electron discharge device **21** having an anode **22**, a control electrode **23**, a cathode **24** and a cathode heater **25**.

The output of electron discharge device **21** is connected in controlling relationship to a first transistor **26** having an emitter **27**, a base **28**, and a collector **29**. Transistor **26** is connected with associated components to form a common emitter circuit. The output of transistor **26** includes a flame relay **30** having a winding **31** and switch means including a movable switch blade **32** and stationary switch contacts **33** and **34**. Flame relay **30** is shown in its deenergized condition in FIGURE 1 wherein switch **32—33** is closed and switch **32—34** is open. Since, as will be apparent, relay winding **31** is supplied with full wave unfiltered D.C. voltage, diode **100** is provided to allow the magnetic flux of the winding to stabilize and to also protect transistor **35** from high transient voltages.

The output of transistor **26** is connected in controlling relation to the input of a second transistor **35** having an emitter **36**, a base **37**, and a collector **38**. Transistor **35** is connected with associated components to form a common base circuit. The output of this second transistor includes a winding **39** of the main burner control relay **40**.

Control relay **40** is provided with a pair of magnetic flux paths identified by reference numerals **41** and **42**. These magnetic flux paths cooperate with a movable armature **43**, the armature being biased to a deenergized position by means of a spring **44**. In the deenergized position of armature **43**, this armature engages a magnetic pole piece **45** associated with the above-mentioned winding **39**. A second pole piece **46** is provided and this pole piece cooperates with a further winding **47**. Winding **47** is the main winding of relay **40** and this winding, when energized, is normally effective to produce a force to cause armature **43** to move from its deenergized position to an energized position wherein the armature engages pole **46**. However, in the event that winding **39** is energized at the time that winding **47** is energized, then the force produced by the energization of winding 39, when added to the force of spring 44, is effective to maintain the armature 43 in its deenergized position, as shown, independent of the state of energization of winding 47.

Armature 43 carries a movable switch blade of normally open switch means designated by means of the reference numeral 48. As seen, this switch means is open when armature 43 is in its deenergized position and is adapted to close when the armature moves to its energized position. Diode 101 is provided to stabilize the magnetic flux of winding 47.

The state of energization of winding 47 is controlled by a means responsive to the need for operation of the fuel burner unit 10 and in this specific instance this means is represented by an automatic control in the form of a thermostat 49 having a normally open switch. This thermostat is effective to close its normally open switch upon a need for operation of the fuel burner unit.

Reference numeral 50 designates a safety cutout means having a normally closed switch 51, a bimetal operator 52 and a heater actuator 53 arranged in cooperating relationship with bimetal 52. Safety cutout means 50 is constructed and arranged such that the means 52—53 function as a time delayed actuator requiring a given time period of energization of heater 53 to warp bimetal 52 to the right to allow the spring blades supporting the contacts of switch 51 to spring apart and thereby open switch 51. Reference numeral 54 designates a manual reset button which is effective to reset the safety cutout means 50 to the position shown after bimetal 52 has cooled sufficiently.

Operating voltage for the apparatus of FIGURE 1 is derived from a pair of power line conductors 55 and 56 which are adapted to be connected to a source of alternating voltage, not shown. These power line conductors are connected to the primary winding 57 of a transformer 58, which transformer is provided with a plurality of secondary windings. One of the secondary windings 59 is connected to a pair of diodes 60 and 61 to form a full wave rectifier, this rectifier being connected to a capacitor 62 to provide a source of D.C. voltage of the polarity indicated. Diode 102 serves to isolate this voltage on capacitor 62 from other voltages present in the circuit. A second secondary winding 63 is likewise connected to a pair of diodes 64 and 65 and as a result thereof the secondary winding and diode combination form a further source of D.C. voltage having a positive terminal at 66 and a negative terminal at 67.

A third secondary winding 68 and a fourth secondary winding 69 are connected in series to form the source of operating voltage for photocell 18. Upon this photocell being subjected to the presence of combustion at the fuel burner unit 10, the photocell becomes conductive to pass current from its anode to its cathode and as a result of this current flow a capacitor 70 is charged to the polarity indicated. The charge on capacitor 70 is distributed through a filter network including resistors 71 and 72 and a further capacitor 73 to charge capacitor 73 to the polarity indicated. As can be seen capacitor 73 is connected with its negative terminal to control electrode 23 of discharge device 21 while the positive terminal of this capacitor is connected to cathode 24. In this manner, as will be more completely described, the presence of combustion at fuel burner unit 10 is effective to bias discharge device 21 to be nonconductive.

When the absence of combustion at fuel burner unit 10 is sensed by photocell 18, discharge device 21 is conductive and secondary winding 69 forms a source of operating voltage for this discharge device such that electrical current flows from the upper terminal of this secondary winding through conductor 74, capacitor 75, discharge device 21, and conductor 76 to the lower terminal of this secondary winding, to thus charge capacitor 75 as indicated.

Transistor 26 is provided with a forward bias which can be seen by tracing a circuit from the positive plate of capacitor 62 through conductors 93 and 78, the emitter-to-base circuit of transistor 26, and resistor 94 to the negative plate of capacitor 62. This transistor is however maintained nonconductive by virtue of capacitor 75 which is connected in parallel with the emitter-to-base circuit of transistor 26. This circuit can be traced from the positive terminal of capacitor 75 through conductor 77, the base-to-emitter circuit of transistor 26, conductors 78 and 79, and resistor 80 to the negative terminal of capacitor 75. In this manner, so long as discharge device 21 is conductive as it is when a flame is not present at fuel burner unit 10, the forward bias for transistor 26 is overcome and the transistor is maintained in a nonconductive condition since the polarity of the voltage on capacitor 75 furnishes a back bias to the base-to-emitter circuit of this transistor.

So long as transistor 26 is in a nonconducting condition, no current flows from the emitter to the collector of this transistor and winding 31 of flame relay 30 is maintained deenergized. Also, transistor 35 is maintained in a nonconducting condition. Since transistor 35 is nonconducting at this time, winding 39 of relay 40 is deenergized.

Upon a need for operation of the fuel burner unit 10, thermostat 49 closes its normally open switch and an energizing circuit for winding 47 of relay 40 can now be traced from the positive terminal 66 through safety cutout switch 51, thermostat 49, conductors 81 and 82, winding 47, conductors 83, 84 and 85, heater 53, and conductor 86 to the negative terminal 67. As a result of this above traced circuit, winding 47 is energized and armature 43 moves from its deenergized to its energized position wherein switch means 48 closes.

The above description has dealt with the normal function of the apparatus wherein photocell, discharge device 21, and transistors 26 and 35 have properly responded to the absence of combustion at the fuel burner unit 10. In the event that any portion of the electronic circuit means including the means 18, 21, 26 and 35 should fail, and in the event that this failure should cause transistor 35 to be falsely conductive, then winding 39 is energized and a subsequent energization of winding 47 due to the closing of thermostat 49 (as above described) is ineffective to move switch means 43 from its open to its closed position.

Normally however the apparatus functions as has been described to close switch 48. The closing of switch 48 completes an energizing circuit for valve 14 and ignition means 15. This energizing circuit can be traced from power line conductor 56 through conductor 87, switch means 48, conductors 88 and 89 to valve 14 and then by way of conductors 90 and 91 to the other power line conductor 55. Ingition means 15 is energized by means of a circuit which can be traced from conductor 88 through the closed switch 32–33, conductor 92, and ignition means 15 to conductor 90. In this manner, fuel is admitted to pilot burner 12 and is ignited by the ignition means. The presence of combustion at pilot burner 12 is sensed by photocell 18 and this photocell becomes conductive, as above described, to charge capacitor 70 to the polarity indicated. This charge is then distributed through resistors 71 and 72 to capacitor 73 to charge this capacitor to the polarity indicated. The voltage on capacitor 73 places a negative cutoff bias on control electrode 23 of discharge device 21 and thereby renders this discharge device nonconductive.

In the absence of conduction of discharge device 21, the voltage present on capacitor 75, which voltage originated as a result of conduction of this discharge device, is dissipated in a relatively short period of time and once this voltage no longer exists, transistor 26 is rendered conductive by means of a forward bias current which can be traced from the positive terminal of capacitor

62 through conductors 93 and 78, the emitter-to-base circuit of this transistor, and resistor 94 to the negative terminal of capacitor 62.

As a result of this bias circuit, transistor 26 becomes conductive and the emitter-to-collector impedance of the transistor is appreciably reduced. This current flow circuit can be traced from the upper terminal of secondary winding 59 through diode 60, conductors 93 and 78, the emitter-to-collector circuit of transistor 26, winding 31 of flame relay 30, the emitter-to-base circuit of transistor 35, and conductors 95, 85, 96 and 97 to the tap of transformer 59. This above traced current flow circuit produces two effects. The first of these effects is to energize the winding 31 of flame relay 30, causing its switch means to move from a deenergized to an energized position wherein switch 32—33 is opened and switch 32—34 is closed. The second effect is to provide a forward biasing current, that is an emitter-to-base current, for transistor 35 to render this transistor conductive.

The opening of switch 32—33 of flame relay 30 is effective to deenergize the ignition means 15 and the closing of switch 32—34 is effective to complete an energizing circuit for valve 13 to thus admit fuel to the main fuel burner 11.

Upon transistor 35 being rendered conductive, the base-to-collector impedance of this transistor is appreciably reduced and as a result of this low impedance, heater 53 of safety cutout means 50 is shorted through low impedance winding 39. It will be remembered that the initial energizing circuit for winding 47 of relay 40 was completed through this heater 53 and the maintaining energizing circuit for winding 47 can now be traced from terminal 66 through switch 51, thermostat 49, conductors 81 and 82, winding 47, conductors 83, 84 and 95, the base-to-collector circuit of transistor 35, winding 39, and conductor 86 to negative terminal 67. In this above traced circuit, transistor 35, upon becoming conductive, places winding 39 in shunt with heater 53. Therefore by designing the resistance of winding 39 to be much lower than the resistance of heater 53, the latter is substantially shorted. In this manner, the sensing of flame at the fuel burner unit is effective to deenergize the ignition means 15 and to energize the main burner valve 13. Furthermore, the sensing of this flame is effective to operatively deenergize heater 53 of the safety cutout means 50 to thereby render the safety cutout means inoperative to place the apparatus in a safety lockout condition. Relay winding 39 is energized at this time. However, since armature 43 has moved to its energized position, energization of winding 39 does not affect the armature.

In the event that flame is not established at pilot burner 12, then discharge device 21 remains in a conductive condition and transistors 26 and 35 remain nonconductive. With transistor 35 nonconductive, the base-to-collector impedance of this transistor remains relatively high and heater 53 of the safety cutout means is not shunted to thereby cause the device to lockout, that is to cause switch 51 to open, after a time period of energization of heater 53. The opening of switch 51, which is in series with thermostat 49, deenergizes winding 47 of relay 40 and thereby allows switch 48 to again open, deenergizing ignition means 15 and pilot valve 14. The apparatus is then in a safety lockout condition.

In the event that a flame failure occurs during a period of energization of the fuel burner unit 10, photocell 18 detects the absence of combustion and discharge device is rendered conductive to once again render transistor 36 nonconductive. This deenergizes winding 31 of the flame relay and switch 32—34 opens to deenergize main valve 13 while switch 32—33 closes to energize ignition means 15 in an attempt to reestablish combustion at the fuel burner unit. Furthermore, transistor 35 is rendered nonconductive to thereby remove the short circuit from heater 53 to operatively energize this heater as the safety

cutout means once again supervises the attempt to establish combustion at the fuel burner unit.

A specific embodiment of the present invention as shown in FIGURE 1 has been constructed utilizing the components as listed below. This specific listing is not however to be construed as a limitation of the present invention.

Discharge device 22	Nuvistor triode A–15133.
Transistors 26 and 35	H71A.
Diode 100	10E5.
Diode 101	10E5.
Diode 102	HD6225.
Secondary winding 59	22.5 volts.
Secondary winding 63	35.2. v. A.C.
Secondary winding 68	190 v. A.C.
Secondary winding 69	64 v. A.C.
Heater 57	40 ohms.
Resistor 71	37M.
Resistor 72	3.3M.
Resistor 80	820 ohms.
Resistor 94	3900 ohms.
Capacitor 62	15 mfd.
Capacitor 70	.002 mfd.
Capacitor 73	.47 mfd.
Capacitor 75	50 mfd.

In the apparatus of FIGURE 1, the initial energizing circuit for winding 47 includes winding 47 and heater 53 connected in series. Winding 47 should for practical reasons have a relatively high impedance with respect to heater 53. This is necessary since the maintaining energizing circuit for winding 47 includes the low impedance base-to-collector circuit of transistor 35 in series circuit with winding 39 of relay 40, and this series circuit is parallel with heater 53. With this type of connection, it is recognized that the initial energizing current through winding 47 is lower than the current which flows through this winding during a running period in which the heater 53 has been substantially shunted by the circuit including coil 39. As a result, the somewhat undesirable effect of having a larger power dissipation in relay 40 during the running period is produced. This effect is limited by having higher impedance in winding 47.

FIGURE 2 provides a circuit in which the power dissipated in its corresponding relay 139 is reduced during the running period, rather than increased as it is in FIGURE 1. Furthermore, in the circuit of FIGURE 2, during the periods at which there is no need for operation of the fuel burner unit, the apparatus is in a condition indicative of the simulated presence of flame. In other words, the presence of combustion is simulated and upon a subsequent need for operation of the fuel burner unit, the apparatus must respond to the actual absence of combustion to thereby check the ability of the apparatus to respond to this condition. After the apparatus has so responded, then it is possible to energize the fuel burner unit and subsequently the apparatus must respond to the actual presence of combustion to deenergize the safety lockout means.

In the apparatus of FIGURE 2 the fuel burner unit 10 has not been shown. However, the photocell or flame sensing means of FIGURE 2, reference numeral 110, performs the identical function to photocell 10 of FIGURE 1. Furthermore, normally open switch 48 and switch means 32, 33 and 34 retain like reference numerals and perform the identical function to that above described in connection with FIGURE 1.

Energizing voltage for the apparatus of FIGURE 2 is derived from a pair of power line conductors 111 and 112 which are adapted to be connected to a source of alternating voltage, not shown. The power line conductors are connected to the primary windings of transformers 113 and 114 respectively, the connection to the primary winding of transformer 114 being made through a normally closed switching device in the form of a limit control which is adapted to be associated with the fuel burner unit or components which are controlled in accordance with the state of energization of the fuel burner unit.

Secondary winding 145 in conjunction with diode 154 and capacitor 181 constitutes a first source of D.C. voltage, controlled by thermostat 142. Secondary winding 158 in conjunction with diodes 159 and 160 and capacitor 161 constitutes a further second source of D.C. voltage.

A secondary winding 116 of transformer 113 is connected to photocell 110 and when this photocell is rendered conductive in the presence of flame at the fuel burner unit, a capacitor 117 is charged to the polarity indicated. The charge on this capacitor is distributed to a filter network including resistors 118 and 119, a further capacitor 120, this further capacitor being charged to a polarity indicated when flame is present.

In this manner, photocell 110 is connected in controlling relation to a low voltage electron discharge device 121 having an anode 122, a control electrode 123, a cathode 124 and a cathode heater 125.

Discharge device 121 is connected in circuit with load means comprising a resistor 126 and a resistor 127, the cathode 124 being connected to resistor 126 and the anode 122 being connected to resistor 127. The portion 127 of this load means is connected in controlling relation to a first transistor 132 having a base 133, an emitter 134, and a collector 135. The portion 126 of this load means is connected in controlling relation to a second transistor 128 having a base 129, an emitter 130 and a collector 131.

As will be more completely explained, the output of transistor 128 is connected in controlling relation to the winding 136 of flame relay 137, this winding 136 also being connected in series with a winding 138 of the main burner control relay 139. Relay 139, which is constructed in a manner similar to relay 40 of FIGURE 1, is also provided with windings 140 and 141. Winding 140 is connected to the output circuit of transistor 132 and winding 141 is connected to be energized directly by means of a thermostat 142, this thermostat 142 being similar to the thermostat 49 of FIGURE 1.

Relay 139 is constructed such that its armature 143 is biased to a deenergized position by means of a spring 144. Winding 138 is associated with the armature 143 to hold the armature in its deenergized position upon energization of winding 138. Windings 140 and 141 are effective, upon joint energization in an additive sense thereof, and upon the absence of energization of winding 138, to cause armature 143 to move from its deenergized to an energized position wherein switch 48 is closed. Once armature 143 moves to the energized position, a subsequent energization of winding 138 is ineffective to cause the armature to return to its deenergized position. Furthermore, once the armature is moved to its energized position, it may be maintained in this position by energization of only winding 141.

Considering the detailed operation of the apparatus of FIGURE 2, the apparatus is shown in a standby condition wherein there is no need for operation of the fuel burner unit.

As will be apparent, in the standby condition both transistor 132 and electron discharge device 121 are inoperative due to the fact that the circuit supplying operating voltage to these components is open at thermostat 142. With this condition prevailing, transistor 128 is in a conductive state to energize both winding 136 of flame relay 137 and winding 138 of main control relay 139. The forward bias which renders transistor 128 conductive is derived from secondary winding 158 of transformer 113, which in conjunction with diodes 159 and 160 is effective to charge capacitor 161 to the polarity indicated. Resistor 126 and resistor 162 are connected in series across capacitor 161 and form a voltage divider. The voltage thus developed across resistor 126 is such that the lower terminal of the resistor is positive with respect to the upper terminal. This lower terminal is connected through resistor 157 to the emitter electrode of transistor 128 and the base electrode of this transistor is connected through conductors 155 and 150 to the negative terminal of resistor 126. Thus, transistor 128 is rendered conductive. The current flow circuit for this transistor can be traced from the positive terminal of capacitor 161 through conductor 156, resistor 157, the emitter-to-collector circuit of transistor 128, conductor 104, winding 136, conductor 165, winding 138, and conductors 166 and 167 to the negative terminal of capacitor 161. Therefore, during the standby condition, flame relay 137 is energized and winding 138 of main burner control relay 139 is energized. Diode 180 is connected to shunt windings 136 and 138 to protect transistor 128 from inductive voltages produced in these windings as their state of energization changes.

Energization of the flame relay causes switch 32—34 to close. It will be remembered, in connection with FIGURE 1, that this switch is connected in circuit with the main burner valve 13. However, this valve is not energized at this time due to the fact that switch 48 is open. The energization of winding 138 of the main control relay 139 insures that switch 48 cannot be closed due to a subsequent joint energization of windings 140 and 141, at least until such time as winding 138 is deenergized.

Assume that there is now a call for operation of the fuel burner unit. This is indicated by the closing of the switch associated with thermostat 142 and this switch completes an energizing circuit for electron discharge device 121 and transistor 128.

It will be remembered that at this time there is no flame present at the fuel burner unit and therefore there is no voltage present across capacitors 117 and 120. Therefore, electron discharge device 121 is now rendered conductive and this current flow circuit can be traced from the upper terminal of secondary winding 145 of transformer 114 through safety cutout switch 146, thermostat 142, conductors 147 and 148, resistor 127, conductor 168, anode and cathode of discharge device 121, conductors 169, 149 and 150, resistor 126, conductors 151, 152, and 153, and diode 154 to the lower terminal of secondary winding 145. From this above traced circuit it can be seen that resistors 126 and 127 constitute load means for discharge device 121.

The voltage developed across resistor 126 due to this above-traced current flow is such that the upper terminal of this resistor is positive with respective to the lower terminal. This polarity of voltage developed across resistor 126 opposes the above described biasing voltage which is developed across this resistor and the magnitude of this voltage is such as to render transistor 128 nonconductive to thereby deenergize the winding of flame relay 137 and to deenergize the winding 138 of control relay 139. In this manner, switch 32–33 of the flame relay is closed.

The voltage developed across resistor 127 is such that the upper terminal of this resistor is positive with respect to the lower terminal. This upper terminal is connected through diode 163 to the emitter of transistor 132 while the negative terminal of this resistor is connected to the base of the transistor. This voltage is a forward bias and transistor 132 is rendered conductive. The current flow circuit for transistor 132 can be traced from the upper terminal of secondary winding 145 through safety cutout switch 146, thermostat 142, conductor 147, diode 163, the emitter to collector circuit of transistor 132, conductor 170, heater 171, conductor 172, winding 140, conductors 173 and 174, and diode 154 to the lower terminal of secondary winding 145. The circuit is effective to energize both heater 171 and winding 140. Therefore the timing period of the safety cutout means is initiated.

As thus far explained, winding 136 of the flame relay has been deenergized, winding 138 of the main control relay has been deenergized, and winding 140 of the main control relay has been energized. The energizing circuit for winding 141 of the main control relay can be traced from the upper terminal of secondary winding 145 through safety cutout switch 146, thermostat 142, conductor 147, diode 163, conductor 175, winding 141, conductors 173 and 174, and diode 154 to the lower terminal of secondary winding 145. Thus, joint energization of winding 141 now exists, and with winding 138 deenergized, armature 143 moves from its deenergized position to its energized position to close switch 48.

The closing of switch 48 energizes the fuel burner unit to produce the sequence of burner unit events as above described in connection with FIGURE 1. It is apparent from the above explanation that in the standby condition, the absence of flame is simulated by virtue of the fact that thermostat 142 in its open condition renders electron discharge device 121 and transistor 132 inoperative. With discharge device 121 inoperative, even though a flame is not present at the fuel burner unit and a resultant voltage is not developed across capacitor 120, this discharge device is ineffective to produce a cutoff bias across resistor 126 and as a result transistor 128 is conductive. Thus, flame relay 137 is energized and a flame is simulated. When thermostat 142 closes to signify a need for operation of the fuel burner unit, it is first necessary that discharge device 121 becomes conductive to sense the actual absence of flame at the fuel burner unit. If discharge device 121 is unable to perform this function, for example, if its heater circuit should open, then the closing of thermostat 142 is ineffective to deenergize winding 138 of control relay 139 and its armature is maintained biased to its deenergized position, even though winding 141 is energized. It will be remembered that in order for winding 140 to be energized transistor 132 must be rendered conductive in response to a bias voltage developed across resistor 127 due to conduction of electron discharge device 121. If a double fault should occur, that is if discharge device 121 is rendered inoperative, for example, due to opening of a heater circuit, and if transistor 132 is rendered conductive even in the absence of the forward biasing voltage across resistor 127 to thus energize winding 140, the armature 143 of relay 139 still is not moved to an energized position due to energization of winding 138. In this manner, completely safe operation of the apparatus is provided.

Normally, discharge device 121 and transistor 132 properly respond to the absence of flame and allow joint energization of windings 140 and 141 of relay 139 to energize the fuel burner unit.

Flame is thus established at the fuel burner unit at this time and, as above described in connection with FIGURE 1, discharge device 121 is rendered nonconductive as photocell 110 detects this flame. As this discharge device is rendered nonconductive, the voltage previously developed across its load means 126 and 127 is no longer present and transistor 128 becomes conductive due to its forward biasing voltage while transistor 132 becomes nonconductive due to the absence of a forward bias voltage across resistor 127.

As transistor 128 becomes conductive, the winding of flame relay 137 is energized and the winding 138 of main control relay 139 is energized. Energization of the winding of flame relay 137 causes switch 32—33 to open to thereby deenergize the ignition means and causes switch 32—34 to close to energize a main burner valve. As has been pointed out, the energization of winding 138 is ineffective at this time to move or control armature 143 since this armature is not in the energized position.

Upon transistor 132 being rendered nonconductive, winding 140 is deenergized and heater 171 is deenergized. The deenergization of winding 140 has no effect at this time since armature 143 is maintained in this energized position by continued energization of winding 141. The deenergization of heater 171 prevents safety lockout of the apparatus, in response to the detection of flame at the fuel burner unit. The apparatus is now in its running condition wherein discharge device 121 is nonconductive, transistor 128 is conductive, and transistor 132 is nonconductive.

In the event that, upon an initial call for operation of the fuel burner unit, combustion was not established at the fuel burner unit, then discharge device 121 remains in a conductive condition, transistor 128 remains nonconductive, and transistor 132 remains conductive. So long as transistor 132 is conductive, winding 141 of relay 139 and heater 171 are both operatively energized. After a time period of energization of heater 171, bimetal 176 is heated sufficiently to cause switch 146 to open, thereby deenergizing relay 139 causing switch 48 to open.

In the event that flame is properly established at the fuel burner unit and for one reason or another the flame subsequently fails, photocell 110 senses this absence of flame and after a short period of time the charge on capacitor 120 is dissipated through resistor 119 and discharge device 121 is rendered conductive. As this discharge device becomes conductive, it is effective, as above described, to render transistor 128 nonconductive and transistor 132 conductive. As transistor 128 becomes nonconductive, the winding 136 of flame relay 137 is deenergized to thereby open switch 32—34 and deenergize the main burner valve and to close switch 32—33 to energize the ignition means to attempt to reestablish flame at the fuel burner unit. Furthermore, the energization of transistor 132 is effective to energize heater 171 of safety cutout means to thereby supervise the attempt to reestablish flame at the fuel burner unit. If this flame is not reestablished within a relatively short time period, safety cutout means is effective to open switch 146 and thereby deenergize main burner control relay 139 to open switch 48.

A specific embodiment of the present invention as shown in FIGURE 2 has been constructed utilizing the components as listed below. This specific listing is not however to be construed as a limitation of the present invention.

Discharge device 121	Nuvistor triode A-15133.
Transistors 128 and 132	H71E.
Diode 163	10E5.
Diode 180	HD6225.
Secondary winding 116	220 v. A.C.
Secondary winding 145	29.5 v. A.C.
Secondary winding 158	21.4 v. A.C.
Heater 171	440 ohms.
Resistor 118	45M.
Resistor 119	2.2M.
Resistor 126	1800 ohms.
Resistor 127	2200 ohms.
Resistor 157	27 ohms.
Resistor 162	5100 ohms.
Capacitor 117	.002 mfd.
Capacitor 120	.68 mfd.

From the above description it can be seen that I have provided an improved burner control apparatus utilizing safety checking features which effectively interlock the operation of the main burner control relay and the flame relay and that this is done without the necessity of providing low voltage switching contacts, with the possibility of resulting malfunction due, for example, to contaminated contacts. Furthermore, in combination with this feature I have provided a novel arrangement for controlling the actuator of the safety cutout means, also without necessitating the use of low voltage switching contacts.

Other modifications of the present invention will be apparent to those skilled in the art and it is therefore intended that the scope of the present invention be limited solely by the scope of the appended claims.

I claim as my invention:

1. Burner control apparatus for use with a fuel burner unit, comprising; an electromagnetic relay having a movable armature and a pair of magnetic flux paths defined

by a first pole having a first winding and a second pole having a second winding, said first and second poles being associated with said armature in the energized and the deenergized positions respectively of said armature, means biasing said armature to normally assume said deenergized position, normally open switch means controlled by said armature to be closed upon said armature assuming said energized position, said switch means being adapted to be connected to energize the fuel burner unit upon said switch means being closed; means connecting said first control winding to be energized upon a need for operation of the fuel burner unit to normally cause said armature to move to said energized position to close said switch means, electronic flame detecting means including a controllable current conducting device having an input and an output, flame sensing means adapted to sense the presence or absence of flame at the fuel burner unit, means connecting said flame sensing means to the input of said current conducting device to render the same nonconductive in the absence of flame at the fuel burner unit, and means connecting the output of said current conducting device to said second control winding to energize the same whenever said current conducting device is conductive, said second control winding being effective to maintain said armature in said deenergized position in the event that said second control winding is energized at the time that said first control winding is energized as a result of a need for operation of the fuel burner unit, such energization of said second control winding being indicative of a malfunction of said electronic flame detecting means.

2. Burner control apparatus for use with a fuel burner unit comprising; an electromagnetic relay having a movable armature spring biased to assume a deenergized position and having a normally open switch which is closed upon said armature assuming an energized position, a first winding operatively assoicated with said armature and effective upon energization thereof to overcome said spring bias and cause said armature to move to said energized position, a second winding operatively associated with said armature and effective when energized to exert a force on said armature when in said deenergized position to aid said spring bias, said second winding being effective when energized with said armature in said deenergized position to prevent movement of said armature to said energized position upon subsequent energization of said first winding, but being ineffective to cause said armature to return to said deenergized position if said armature is in said energized position at the time that said second winding is energized, means including said normally open switch adapted to be connected to a fuel burner unit to energize the fuel burner unit and establish combustion thereat upon said switch means being closed, electronic flame detecting means including a controllable current conducting device having an input and an output, flame sensing means adapted to sense the presence or absence of combustion at the fuel burner unit, means connecting said sensing means to the input of said current conducting device to render the same nonconductive in the absence of combustion at the fuel burner unit, further circuit means connecting said second winding to the output of said current conducting device to energize said second winding upon said sensing means sensing the presence of combustion at the fuel burner unit, and further means including means responsive to the need for operation of the fuel burner unit connected to energize said first winding in the event of such a need, said first winding then being effective to cause said switch to close to establish combustion at the fuel burner unit, said means responsive to the need for operation of the fuel burner unit being ineffective to cause such energization of the fuel burner unit in the event that said second winding is energized to falsely indicate that combustion is present at the fuel burner unit at a time when the fuel burner unit is in fact deenergized.

3. Burner control apparatus for use with a fuel burner unit and means responsive to the need for operation of the fuel burner unit, comprising; safety lockout means having a time delayed actuator; a control relay having normally open switch means adapted to be connected to the fuel burner unit, a first winding adapted to be connected through said safety cutout actuator to the means responsive to the need for operation of the fuel burner unit, and a second winding, said first and second windings being operatively associated with said switch means to cause said switch means to close only in the event that said first winding is energized prior to the energization of said second winding; flame sensing means adapted to be positioned to sense the presence or absence of flame at the fuel burner unit; electronic switching means including a controllable current conducting device having an output and an input, means connecting said input to be controlled by said flame sensing means to render said current conducting device nonconductive in the absence of flame at the fuel burner unit, means connecting said output in a series circuit with said second winding, and means connecting said series circuit in parallel with said safety lockout actuator, said last named means functioning upon a malfunction of said flame sensing means to prevent the closing of said switch means upon a subsequent need for operation of the fuel burner unit, said last named means also functioning upon the establishment of flame at the fuel burner unit followed by proper functioning of said flame sensing means to shunt said safety lockout actuator and thereby render said safety lockout means inoperative to perform its lockout function.

4. Burner control apparatus for use with a fuel burner unit having means responsive to the need for operation of the fuel burner unit, comprising; a control relay having normally open switch means and a first and second winding, said normally open switch means being adapted to be connected to the fuel burner unit to energize the same upon closing of said normally open switch means, said first winding being operatively associated with said switch means to normally close the same upon energization of said first winding, said second winding being operatively associated with said switch means to prevent the closing of said switch means by energization of said first winding when said second winding is energized at the time that said first winding is energized; flame sensing means adapted to be positioned to sense the presence or absence of flame at the fuel burner unit, first electronic switch means, means connecting said flame sensing means in controlling relation to first electronic switch means, said first electronic switch means being in a conductive state in the absence of flame at the fuel burner unit, a first source of voltage, circuit means including said first winding and terminals adapted to be connected to the means responsive to the need for operation of the fuel burner unit to connect said first electronic switch means to said first source of voltage upon a need for operation of the fuel burner unit to thereby render said first electronic means conductive upon the proper sensing of the absence of flame at the fuel burner unit; a second source of voltage; second electronic switch means connected in circuit with said second winding to said second source of voltage, means connecting said second electronic switch means to be controlled by said first electronic switch means to render said second electronic switch means conductive to thereby energize said second winding at all times that said first electronic switch means is nonconductive; the apparatus thereby functioning to energize said second winding during a period in which there is no need for operation of the fuel burner unit, and upon a subsequent need for such operation said first electronic switch means is normally rendered conductve to thereby render said second electronic switch means non-conductive to de-energize said second winding and allow said control relay switch means to close as a result of energization of said first winding; and further

means adapted to maintain said control relay switch means in a closed condition once the switch means is moved to the closed condition.

5. Burner control apparatus for use with a fuel burner unit having means responsive to the need for operation of the fuel burner unit, comprising; a control relay having normally open switch means and first, second and third wndings, said first and third windings being operatively associated with said switch means to normally close the same upon joint energization of said first and third windings, said second winding being operatively associated with said switch means to prevent the closing of said switch means by said joint energization of said first and third windings when said second winding is energized at the time of said joint energization; a first source of voltage; flame sensing means adapted to be positioned to sense the presence or absence of flame at the fuel burner unit; an electron discharge device having load means and having an input connected to said flame sensing means, said discharge device being in a conductive state in the absence of flame at the fuel burner unit; a first transistor having an input connected to said load means to render said first transistor conductive upon discharge device being rendered conductive and having an output connected to said first winding to energize the same upon said first transistor being rendered conductive; circuit means including said first source of voltage adapted to be completed by the means responsive to the need for operation of the fuel burner unit to apply an operating voltage to said discharge device and to said first transistor to thereby render said discharge device and said first transistor conductive and to thereby energize said first relay winding upon a need for operation of the fuel burner unit and upon said discharge device and said flame sensing means properly responding to the absence of flame at the fuel burner unit; a second source of voltage; a second transistor having an input connected to said load means to render said second transistor conductive upon said discharge device being nonconductive and having an output connected directly to said second source of voltage and said second winding to energize said second winding upon said second transistor being rendered conductive; and further circuit means including the means responsive to the need for operating of the fuel burner unit adapted to energize said third winding, said third winding when energized serving to maintain said relay switch means in a closed condition once it has moved from the normal open condition to a closed condition.

6. Burner control apparatus for use with a fuel burner unit having means responsive to the need for operation of the fuel burner unit, comprising; a control relay having normally open switch means and first, second and third windings, said first and third windings being operatively associated with said switch means to normally close the same upon joint energization of said first and third windings, said second winding being operatively associated with said switch means to prevent the closing of said switch means by said joint energization when said second winding is energized at the time of said joint energization; flame sensing means adapted to be positioned to sense the presence or absence of flame at the fuel burner unit; an electron discharge device having load means and having an input connected to said flame sensing means, said electron discharge device being in a conductive state in the absence of flame at the fuel burner unit, a first transistor having an input connected to said load means to render said first transistor conductive upon said discharge device being rendered conductive; safety cutout means having a time delayed electrically energizable actuator; circuit means connecting said first winding and the actuator of said safety cutout means in circuit with the output of said first transistor to energize the same upon said first transistor being rendered conductive; a first source of voltage; circuit means including said first source of voltage adapted to be completed by the means responsive to the need for operation of the fuel burner unit to energize said third relay winding only upon a need for operation of the fuel burner unit and to apply operating voltage to said discharge device and to said first transistor to thereby normally render the same conductive to thereby energize said first relay wnding and said time delay actuator only upon a need for operation of the fuel burner unit and upon said discharge device and said flame sensing means properly responding to the absence of flame at the fuel burner unit; a second source of voltage; a second transistor having an input connected to said load means to render said second transistor conductive upon said discharge device being rendered nonconductive in response to the presence of flame at the fuel burner unit, and circuit means connecting the output of said second transistor directly to said second source of voltage and to said second relay winding to thereby energize said second winding upon said second transistor being rendered conductive.

7. Burner control apparatus for use with a fuel burner unit having means responsive to the need for operation of the fuel burner unit; comprising; a control relay having normally open switch means and a first and second winding, said first and second windings being operatively associated with said switch means and being effective to control the same to cause said switch means to close when said first winding is energized in the absence of energization of said second winding, and said second winding being ineffective to cause said switch means to open if energized subsequent to energization of said first winding; circuit means adapted to be connected to the fuel burner unit to energize the same and establish combustion thereat upon said relay switch means being closed; combustion sensing means including means adapted to be positioned to sense the presence or absence of combustion at the fuel burner unit; first electronic switching means having an input and having an output connected to said first winding, means including said combustion sensing means connected to the input of said first electronic switching means to energize said first winding in the absence of combustion at the fuel burner unit; second electronic switching means having an input and having an output connected to said second winding, means including said combustion sensing means connected to the input of said second electronic switching means to energize said second winding in the presence of combustion at the fuel burner unit; means connecting the means responsive to the need for operation of the fuel burner unit in controlling relation to the means including said combustion sensing means to render the same inoperative to sense the absence of combustion at the fuel burner unit and to simulate the presence of such combustion when there is no need for operation of the fuel burner unit, said second relay winding thereby being energized during periods in which there is no need for operation of the fuel burner unit, a subsequent need for such operation causing said combustion sensing means to be rendered operative to sense the actual absence of combustion at the fuel burner unit whereby said second winding is de-energized and said first winding is energized to close said relay switch means and energize the fuel burner unit; and further means controlled by the means responsive to the need for operation of the fuel burner unit to maintain said relay switch means in a closed condition so long as there is a need for operation of the fuel burner unit.

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