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BURNER SAFETY CONTROL SYSTEM

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2 Sheets-Sheet 1

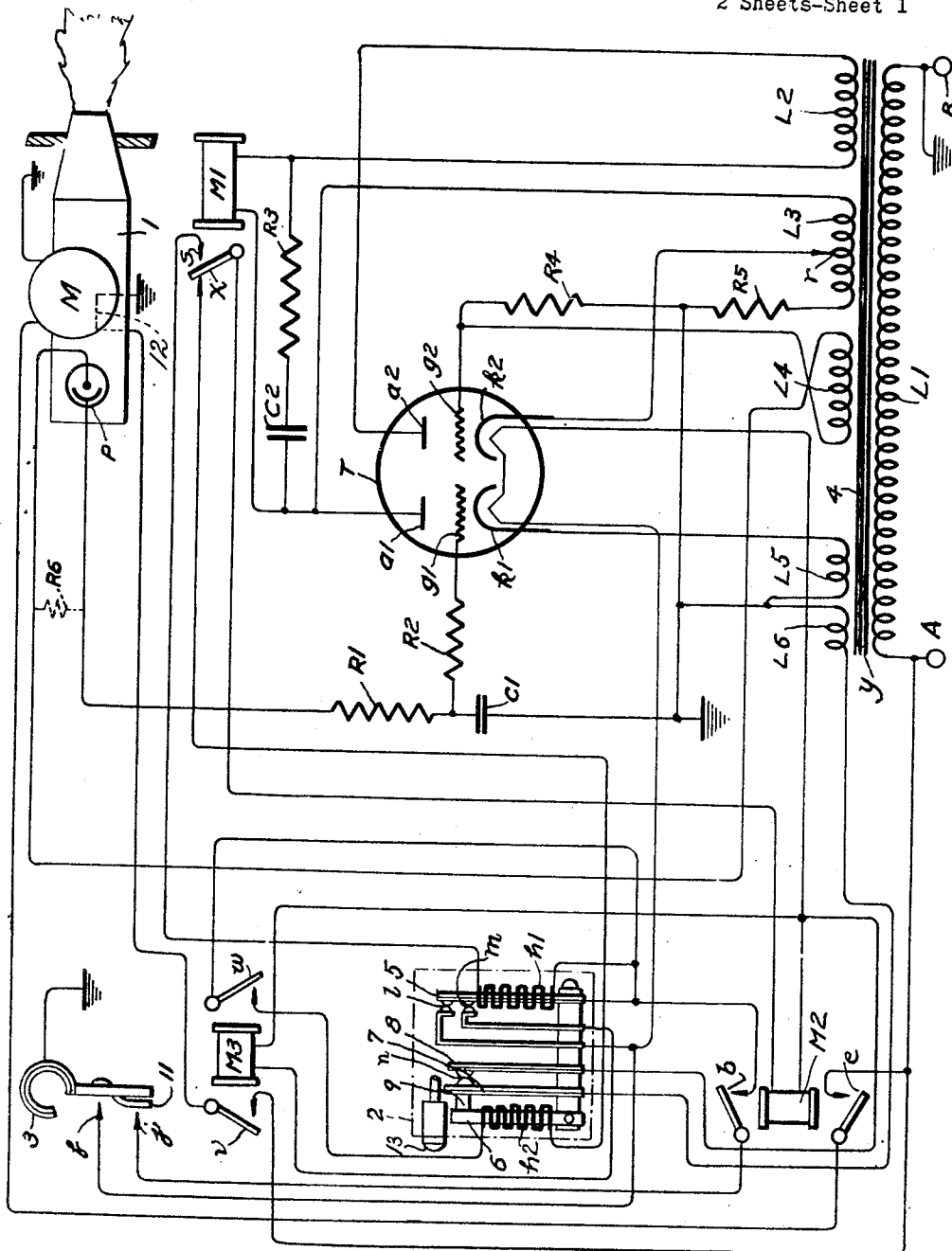


Fig. 1.

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2 Sheets-Sheet 2

Fig. 2.

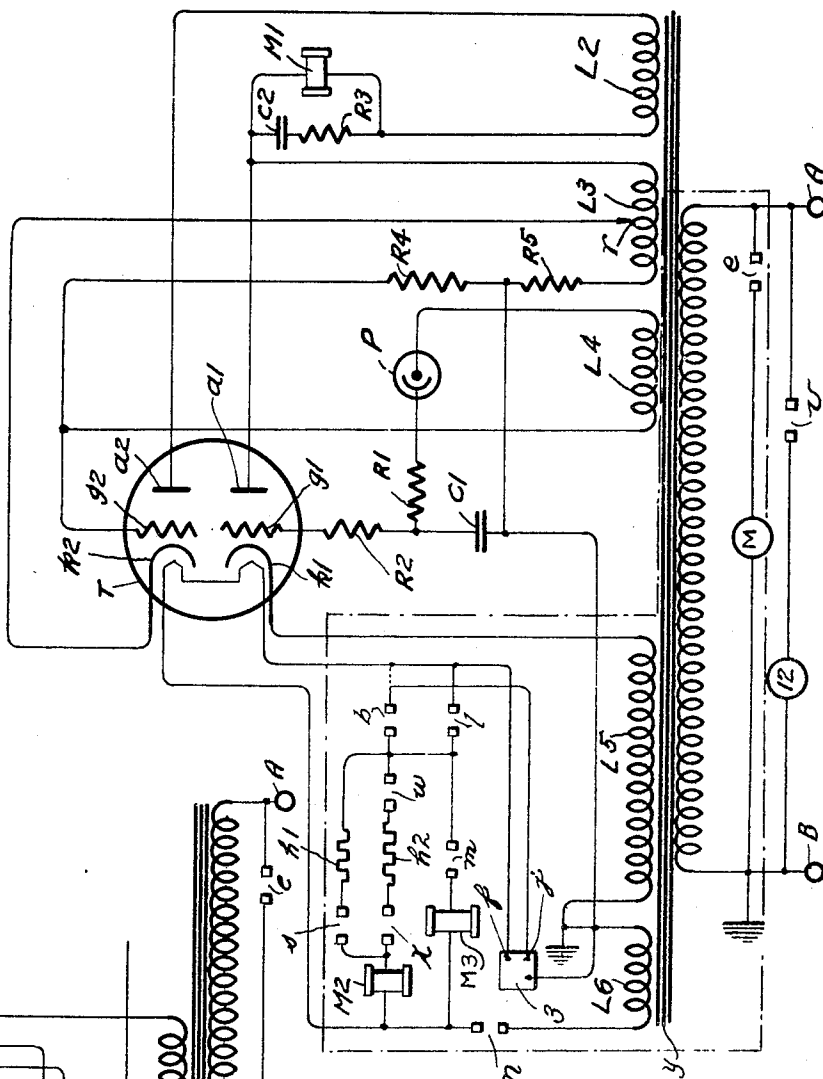
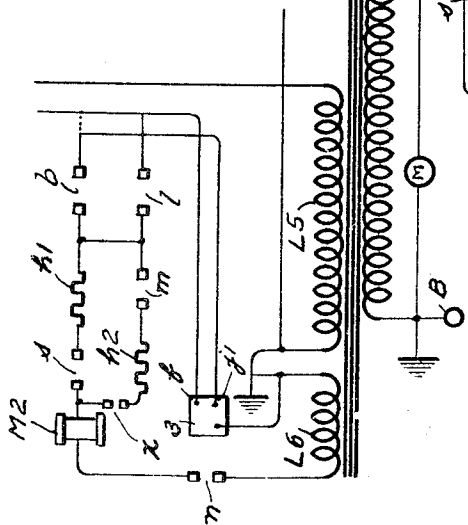


Fig. 3.



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BURNER SAFETY CONTROL SYSTEM

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6 Claims. (Cl. 158—28)

1

This invention relates to the control of burners in heating plants, and more especially to the control of oil burners of the type used in house heating installations where completely automatic operation is desirable and where safety is of the utmost importance.

It is well known by those familiar with the operation of oil burners that, if the flame in a burner goes out, for any cause such as momentary failure of the fuel supply, it is essential that the burner motor be immediately shut down, as the injection of fuel into the hot combustion chamber is likely to result in an explosion. It is further essential, when the burner motor is shut down, for the above or any other reason, to prevent operation of the motor until sufficient time has elapsed to permit combustible gases to escape from the furnace, and the furnace walls to cool to a safe temperature. It is further necessary to render the flame failure safeguard inoperative for a certain period when the burner motor is first started, to allow sufficient time for the fuel to ignite.

Many of the devices now used to detect flame failure depend upon lowering of the temperature in some part of the furnace for their operation. As this temperature may fall slowly, the motor of the burner may continue to run for some time after the flame is extinguished with the resulting danger of explosion. Certain other devices which depend on the conductivity of the flame, frequently become covered with soot and may operate erratically if the flame fluctuates in shape or intensity.

Certain of the features here disclosed are claimed in copending application, Serial No. 126,522, filed November 10, 1949.

It is the main object of this invention to provide a control which allows for automatic regulation of the temperature in the house in the usual manner, by means of a room thermostat, and at the same time absolutely insures against explosion by shutting down the burner motor immediately when flame failure occurs.

Another object is to provide a control which is reliable under all conditions normally encountered in a house heating installation.

Another object is to provide a control which shuts down the burner motor upon failure of such components of the control itself as are liable to wear out in normal service.

Another object is to provide a control readily adaptable to operate with various types of conventional room thermostats.

Another object is to provide a control which

2

is insensitive to momentary fluctuations in the flame.

Another object is to provide a control which allows for the normal operating cycles of the various makes of oil burners and types of ignition ordinarily used in home heating installations.

These and other objects, advantages, and features will be apparent from the following description. The description refers to drawings in which

Fig. 1 is a schematic representation of the complete control system of an oil burner using a device constructed in accordance with the invention;

Fig. 2 is the circuit diagram of the control system shown in Fig. 1;

Fig. 3 is a partial circuit diagram showing the arrangement of the part in Fig. 2 enclosed by the dotted line when the control is operated with an oil burner of the type which does not require control of the ignition system.

Referring now to Figs. 1 and 2, 1 is an oil burner of any conventional type having a motor M, and an ignition system 12 adapted to be turned on for a certain period when the burner is first started. The ignition system may be of any well-known form, for example a high-voltage transformer and spark contacts (not shown), and is indicated by a dotted line 12 in the wind pipe of the burner 1 connected in the ignition circuit. P is a photocell mounted either in the wind pipe of the burner or in some other appropriate location giving direct view of the flame. 3 is a thermostat of any conventional type, here shown as the type having two contacts one of which makes or breaks before the other for the purpose of providing a temperature differential. 2 is a thermal program switch of the type described in Patent Number 2,425,164, dated August 5, 1947. As described in the above named patent, bimetallic strip 5, when cool, holds contacts l and m closed. Passage of current through coil h1 heats strip 5 and causes the strip to bend, opening first contact l and then contact m. Bimetallic strip 6, when cool, is in such a position that insulating button 9 presses against spring strip 7 and holds contact n closed. Passage of current through coil h2 causes strip 6 to bend in a direction at right angle to strip 7. When button 9 passes beyond the edge of strip 7, strip 7 springs back, opening contact n. Bimetallic strip 6 may then not return to its original position even though current ceases to pass

through coil *h2* until strip 7 has been reset manually by means of button 13.

4 is a transformer having a primary L1 and independent secondaries L2, L3, L4, L5, and L6. M1 is a relay having one contact *s* normally open and one contact *x* normally closed when the relay is deenergized. The mechanical arrangement of relay M1 is such that the armature acts to close contact *s* before opening contact *x*. M2 is a relay having contacts *b* and *e* normally open when the relay is deenergized. M3 is a relay having contacts *v* and *w* normally open. Tube T is preferably a double triode having anodes *a1*, *a2* cathodes *k1*, *k2* and control grids *g1*, *g2*. Tube T may be replaced by two separate triodes without affecting the operation of the device. A and B are terminals supplied with alternating current. The operation of the device is as follows:

Contacts *f* and *j* of thermostat 3 are normally open when the temperature in the surrounding atmosphere is above a certain predetermined value. When the temperature falls below this value, first contact *j* closes, then contact *f*. If relay M2 is deenergized, the closing of contact *f* has no effect as the circuit is still open at *b*. When contact *f* is closed, however, a circuit path is established from ground through contact *f*, *l*, *m*, M3, *n*, and secondary L6 and also the circuit through the heater of tube T, from ground through contact *f*, the heater, contact *n* and secondary L6. Relay M3 is energized closing contact *v* and *w*. The closing of contact *v* completes the circuit through the oil burner ignition system 12. The closing of contact *w* completes the circuit from ground—*f*—*l*—*w*—*h2*—*x*—M2—*n*—secondary L6. Relay M2 is then energized closing contacts *b* and *e*. The closing of contact *e* starts burner motor *m*. The closing of contact *b* completes the circuit ground—*j*—*b*—*w*—*h2*—*x*—M2—*n*—L6. This circuit acts as a holding circuit for relay M2 so that even though contact *f* is broken the relay is not again deenergized until *j* is broken also.

The ignition system being on and the motor running the burner normally ignites in a few seconds. After a short period the cathodes of tube T1 are sufficiently heated to become emissive. The passage of current through heater *h2*, causes bimetallic strip 6 to start to bend. In this device the characteristics of the various elements are such that, in normal operation tube T is in the emissive condition and the burner is ignited causing light to fall on phototube P before the safety contact *n* has opened. The impedance of phototube P is then low. During the half cycle when point *y* of transformer 4 is positive, the anode *a1* of tube T is negative with respect to cathode *k1* and anode *a2* is negative with respect to cathode *k2* so that neither section of tube T is conducting. Grid *g1* being positive with respect to cathode *k1* on this half cycle, grid current flows in the first section of the tube from *g1* to *k1* charging condenser C1. Grid *g2* also being positive with respect to its cathode, grid current flows from L3 through R5, R4, *g2*, *k2* to tap *r*. The anode of the phototube being negative with respect to its cathode, no current flows through the phototube.

During the half cycle when point *y* is negative, anode *a1* is positive with respect to cathode *k1*. The charge received by condenser C1 during the preceding half cycle and the potential of secondary L5 tend to make grid *g1* negative with respect to cathode *k1*. On this half cycle, however, the anode of the phototube is positive with respect

to its cathode and if the phototube P is illuminated, the current flowing through secondary L4, phototube P, R1 and R4 is sufficient to neutralize the charge on condenser C1. The potential of L5 is less than the cut-off bias of the tube. Current flows from the positive end of secondary L3 through the first section of tube T1, secondary L5, and resistor R5 to the negative end of secondary L3. The current flowing in resistor R5 tends effectively to raise the potential of grid *g2* with respect to cathode *k2* and the current flowing in resistor R4 tends to lower the potential of grid *g2*. The values of resistors R4 and R5 are such that, under normal operating conditions when phototube P is receiving light, the bias on grid *g2* is also less than the cut-off value. Since plate *a2* is positive with respect to cathode *k2*, current flows from the positive end of secondary L2 through the second section (*a2* to *k2*) of tube T1, tap *r*, secondary L3, relay M1, to the negative end of secondary L2, and relay M1 becomes energized.

When relay M1 becomes energized contact *s* is closed and contact *x* is opened. The closing of contact *s* establishes a holding circuit for relay M2 through secondary L6—*n*—M2—*s*—*h1*—*b*—*j* to ground, and a second holding circuit by way of strip 5—contacts *l*—*j* to ground. The breaking of contact *x* interrupts the circuit through heater *h2* so that bimetallic strip 6 is no longer heated. Since relay M1 is normally energized before contact *n* is broken, strip 6 returns to its original position. The current now flowing through heater *h1* causes strip 5 to bend, opening first contact *l*, then contact *m*. The opening of contact *l* breaks the circuit to contact *f* of thermostat 3. The opening of contact *m* breaks the circuit from ground to contact *j*—*b*—5—*m*—M3—*n*—L6 to ground so that the ignition relay M3 becomes deenergized. The circuit through M2 is then held only through thermostat contact *j*, contact *b*, heater *h1*, contact *n* and contact *s* of relay M1 and the system is in normally running condition.

If the flame failure occurs, light no longer falls on phototube P. During the half cycle when point *y* is positive condenser C1 becomes charged by the passage of current through grid *g1* as before. During the half cycle when point *y* is negative, the impedance of phototube P being high, the current flowing through phototube P, resistors R1 and R4 and secondary L4 is insufficient to neutralize the charge on condenser C1 so that grid *g1* becomes biased below cut-off and the first section of tube T1 becomes non-conductive. Now no current flows through the resistor R5, and under this condition grid *g2* also becomes biased below cut-off and the second section of tube T1 becomes non-conductive. Relay M1 then becomes deenergized allowing contact *s* to open.

The opening of contact *s* interrupts the current through heater *h1* and deenergizes relay M2, shutting down the burner motor by the opening of contact *e*. Bimetal 5 starts to cool and, after a certain period of time returns to its original position closing first contact *m*, then contact *l*. If the thermostat contacts are still closed, the closing of contacts *m* and *l* again establishes the circuit through relay M3 and the burner goes through its starting cycle. If flame is established, normal operation is resumed. If no flame is established, phototube P receives no light and relay M1 remains deenergized. Heater *h2* is not cut out and bimetal 6 continues to bend until contact *n* opens. As described in Patent Number 2,475,164, dated August 5, 1947 spring strip 7 pre-

vents bimetal 6 from returning to its original positions upon cooling so that contact *n* remains open until the apparatus is reset manually.

Resetting of contact *n* allows the burner to be started by closing of the thermostat contacts as before. If the cause of flame failure was only temporary, the flame is reestablished, phototube P becomes conductive, relay M1 becomes energized as previously described, and contacts *l* and *m* again open. If no flame is established, current continues to flow through heater *h2* by way of contact *x* and contact *n* again opens. Continuous operation of the burner is thus prevented until the cause of flame failure has been rectified. The burner may likewise be shut down if the rising temperature in the neighborhood of the thermostat causes the thermostat contacts to open. The opening of *f* has no effect as the circuit is held through *j*. The opening of *j* breaks the circuit through relay M2 shutting down the burner. As previously explained the burner cannot again be started until bimetal 5 has cooled closing contacts *l* and *m*. Furthermore if the burner should fail to ignite within the starting interval after closing of the thermostat contacts it is evident that safety contact *n* will be opened as previously described. The control thus insures against all normal contingencies in burner operation.

If a thermostat of the two-wire type is used the connection from *j* to *b* is not employed and a connection is made according to the dotted line in Fig. 2 from *b* to *f*. The operation of the control with this connection is apparent from a study of the drawing together with the foregoing description.

When the control is used on oil burners of the constant ignition type, so that no automatic control is required on the ignition system, relay M3 is omitted and connections are made as shown in Fig. 3. With this arrangement the closing of thermostat contact *f* establishes a circuit from ground—*f*—*l*—*m*—*h2*—*x*—M2—*n*—L6. When relay M2 becomes energized a holding circuit is established through *j*—*b*—*m*—*h2*—*x*—M2—*n*—L6. When relay M1 becomes energized, contact *x* opens breaking the circuit to *f* through *h2* and contact *s* closes establishing the circuit through *j*—*b*—*h1*—*s*—M2—*n*—L6. The operation of the phototube and amplifying network remain the same as described in the reference to Fig. 1. As in Fig. 2, the two wire type of thermostat may be used with the connection shown in dotted line from *b* to *f*.

One advantage of this device is the arrangement of the two heater connections in such a manner that either heater *h1* or heater *h2* may be connected in series with relay M2 but not both simultaneously, except for the brief period required for the travel of the armature of relay M1. The resistance of the heater elements may be approximately of the same magnitude so that the current through M2 is substantially the same during both the starting and the operating periods, thus avoiding the necessity of overloading the relay coil during one period or the other.

As previously set forth in the objects, one novel and important feature of this invention is its safe operation under all conditions. Heating plants are customarily shut down for several months of the year and during this time a considerable amount of moisture may be absorbed by, or deposited on, the phototube base and socket, causing leakage of current across the phototube when the control is first turned on. Furthermore, when the burner is in operation, the phototube

may be exposed to a relatively high ambient temperature. Under this condition, evaporation of light sensitive material from the cathode is accelerated. The deposit of this material on the envelope of the tube causes a gradually increasing amount of internal leakage between the anode and cathode leads.

The effect of leakage due to the above causes or accidental short-circuit may be illustrated by considering the action of the control when a resistor shown as R6 in Fig. 1 is placed in parallel with the phototube. Assuming first that R6 is large, a small amount of current passes across the phototube on both half cycles. Since this current is alternating, it has no effect on the average charge of condenser C1. Condenser C1 becomes charged by grid current on the half cycle when *y* is positive and, if the phototube is illuminated, a rectified current is applied to C1 tending to neutralize the charge as previously explained. If the value of R6 is large compared to the impedance of the illuminated phototube, the control will continue to function. As R6 is gradually reduced to a value comparable with the reactance of the condenser C1, then R1, R6, and C1 would ordinarily tend to act as a voltage dividing network and the potential of *g1* would become higher with respect to the potential of cathode *k1* as the impedance of R6 became lower. As a consequence, if the phototube P were to be short-circuited, the first half of tube T (anode *a1* to cathode *k1*) would remain conductive and the furnace would remain in operating condition upon flame failure. Provision is made in this circuit, however, to eliminate such an unsafe condition. The resistance R4 which is connected in the grid circuit of the second half of the tube (grid *g2*, cathode *k2*) is also connected in the supply circuit of the phototube P. The grid current flowing in the second half of the tube during alternate half cycles, gives rise to a rectified potential across R4. It will be noted that during the cycle when this potential exists, the phototube is in its non-conductive half cycle and the potential across R4 does not, under normal conditions, effect the charge on condenser C1. When the phototube is bridged by a non-rectifying impedance, however, such as R6, the rectified potential across R4 tends to apply a charge on C1 which is in such a direction as to drive grid *g1* negative. As the resistance of R6 gradually decreases, the charge on C1 due to grid rectification current across R4 builds up until a point is reached where the negative bias on grid *g1* is sufficient to cut off the first section of the tube. When the first section of the tube T becomes non-conductive, the positive bias supplied by R5 to grid *g2* is eliminated and grid *g2* becomes negative with respect to its cathode cutting off the second section of the tube. Relay M1 then becomes deenergized shutting down the burner. A short-circuit across the phototube results in deenergization of M1 in the same manner.

Furthermore, as R6 is gradually reduced in value, the current through the phototube for a given light intensity is correspondingly reduced. Under conditions of leakage exceeding a certain amount, therefore, both sections of tube T become and remain non-conductive regardless of the presence or absence of flame and the burner is shut down. As previously described, the starting cycle of the burner may then be repeated, but since relay M1 does not become energized, safety contact *n* opens. The burner cannot be continu-

ously operated until the phototube has been replaced or the cause of short-circuit removed.

The effect of any bi-directional impedance, such as capacity between the phototube leads may be explained in a similar manner. In this control the values of the various elements are such that any reasonable length of leads may be used without substantially affecting the sensitivity.

In the foregoing description and in the drawings, P has been shown as a phototube, but it is evident that this circuit would perform its function equally well if P were replaced by any device suitable for detecting the presence or absence of flame and substantially rectifying in character, for example a rod arranged to make contact through the flame to ground, the flame itself acting as a rectifying impedance.

It should be noted that during normal operation of the burner 1 both sections of tube T are maintained conductive. If either section's electron stream should, for any reason fail, relay M1 would be deenergized, and the burner would shut down automatically, as described above. This is so because the establishment of a flow of current through the first section and hence through resistor R5 is necessary before current can flow in the second section. Thus in this device, it is not possible for the burner to continue to function in the presence of a defective amplifier tube.

Since certain changes may be made in the above-described article and different embodiments of the invention could be made without departing from the scope thereof, it is intended that all matter contained in the above-description or shown in the accompanying drawing shall be interpreted as illustrative only and not in a limiting sense.

I claim:

1. A control for a fuel burner comprising: fuel igniting means adapted to ignite said fuel; first electrically operated means for energizing said fuel igniting means; burner operation initiating means; second electrically operated means for actuating said initiating means in response to said first electrically operated means being energized; a first electro-thermal time delay switch, having a normally closed contact connected in the energizing circuits of both said electrically operated means, and operated by a first electrical heat generating element in the energizing circuit of said second electrically operated means; a second electro-thermal time delay switch, having a normally closed contact connected in the energizing circuit of said first electrically operated means, and operated by a second electrical heat generating element; and relay means responsive to the presence of flame at said burner, and arranged substantially simultaneously to switch said first heat generating element out of and said second heat generating element into said energizing circuit of said second electrically operated means, whereby one or the other of said heat generating elements is at all times in said last mentioned energizing circuit.

2. Apparatus in accordance with claim 1 in which said first time delay switch is set to operate after an interval greater than the time normally required for said burner to ignite and for said relay means to operate in response to the presence of said flame, and is provided with latching means to hold said first switch contact open once opened, and with resetting means for releasing said latching means.

3. A control for a fuel burner comprising: fuel igniting means adapted to ignite said fuel; first electrically operated means for energizing said fuel igniting means; burner operation initiating means; second electrically operated means for actuating said initiating means in response to said first electrically operated means being energized; a first electro-thermal time delay switch, having a normally closed contact connected in the energizing circuits of both said electrically operated means, and operated by a first electrical heat generating element connected in the energizing circuit of said second electrically operated means; a second electro-thermal time delay switch, having a normally closed contact connected in the energizing circuit of said first electrically operated means, and operated by a second electrical heat generating element; and relay means responsive to the presence of flame at said burner, and arranged substantially simultaneously to switch said first heat generating element out of and said second heat generating element into said energizing circuit of said second electrically operated means, whereby one or the other of said heat generating elements is at all times in said last-mentioned energizing circuit; said relay means being operative upon extinguishment of said flame to switch said second heat generating element out of and said first heat generating element back into said energizing circuit of said second electrically operated means, and said second time delay switch means being constructed and arranged to maintain said second switch contact means open for a predetermined period of time after said second heat generating element is switched out of said energizing circuit and thereby de-energized.

4. Apparatus in accordance with claim 3 in which said first time delay switch is set to operate after an interval greater than the time normally required for said burner to ignite and for said relay means to operate in response to the presence of said flame, and is provided with latching means to hold said first switch contact open once opened, and with resetting means for releasing said latching means.

5. A control for a fuel burner comprising: fuel igniting means adapted to ignite said fuel; burner operation initiating means; a first relay, controlling a contact which is connected in the energizing circuit of said initiating means; a second relay, controlling two contacts, one of which is connected in the energizing circuit of said fuel igniting means and the other of which is connected in the energizing circuit of said first relay; a first electro-thermal time delay switch, having a normally closed contact connected in the energizing circuits of both said relays, and operated by a first electrical heat generating element connected in the energizing circuit of said first relay; a second electro-thermal time delay switch, having a normally closed contact connected in the energizing circuit of said second relay, and operated by a second electrical heat generating element; and relay means responsive to the presence of flame at said burner, and arranged substantially simultaneously to switch said first heat generating element out of and said second heat generating element into said energizing circuit of said first relay.

6. Apparatus in accordance with claim 5 in which said first time delay switch is set to operate after an interval greater than the time normally required for said burner to ignite and for said flame-responsive relay means to operate in

response to the presence of said flame, and is provided with latching means to hold said first switch contact open once opened, and with re-setting means for releasing said latching means.

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