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2,839,129

SAFETY CONTROL UNIT FOR OIL BURNERS AND THE LIKE

Filed April 12, 1956

2 Sheets-Sheet 1

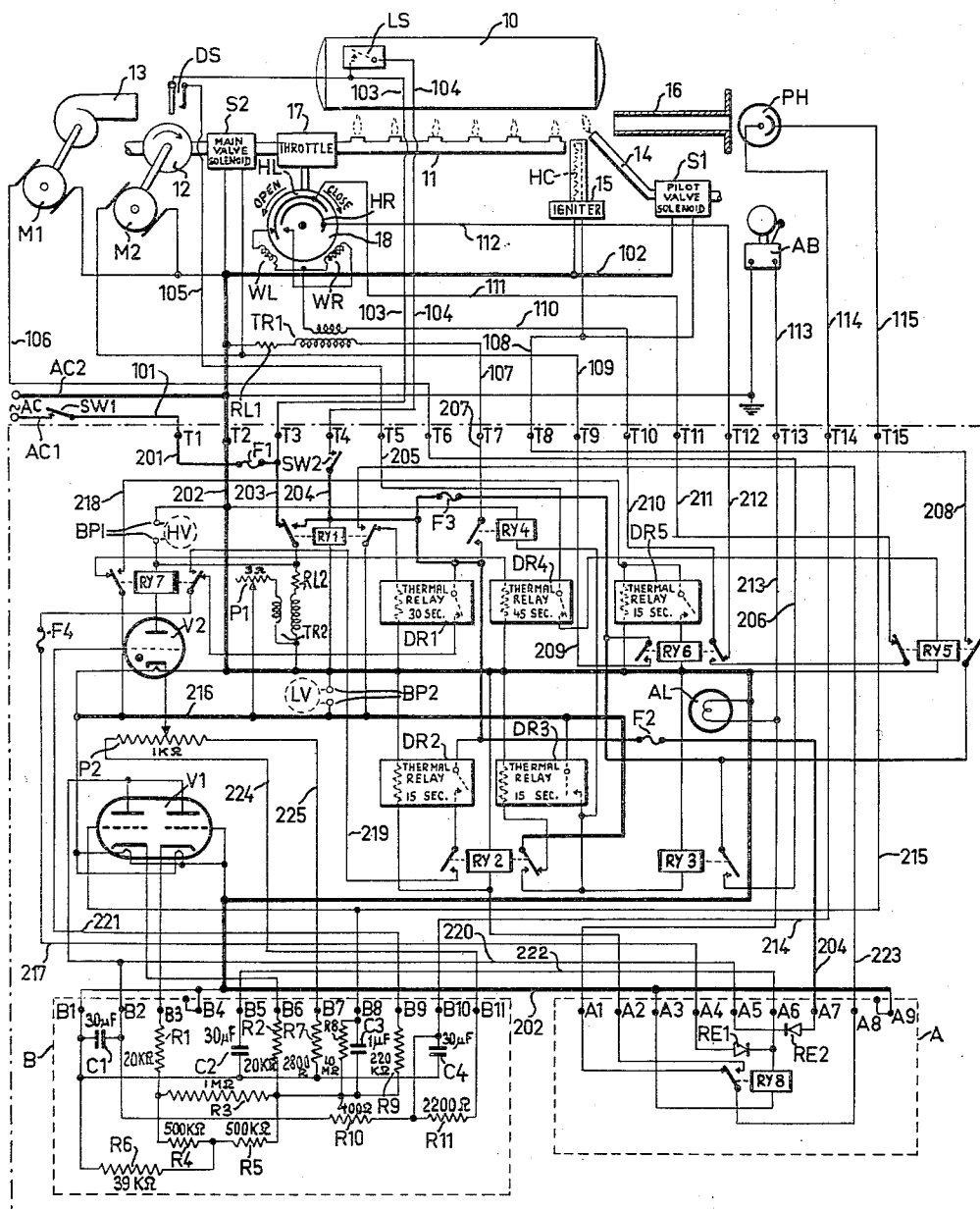


FIG. 1

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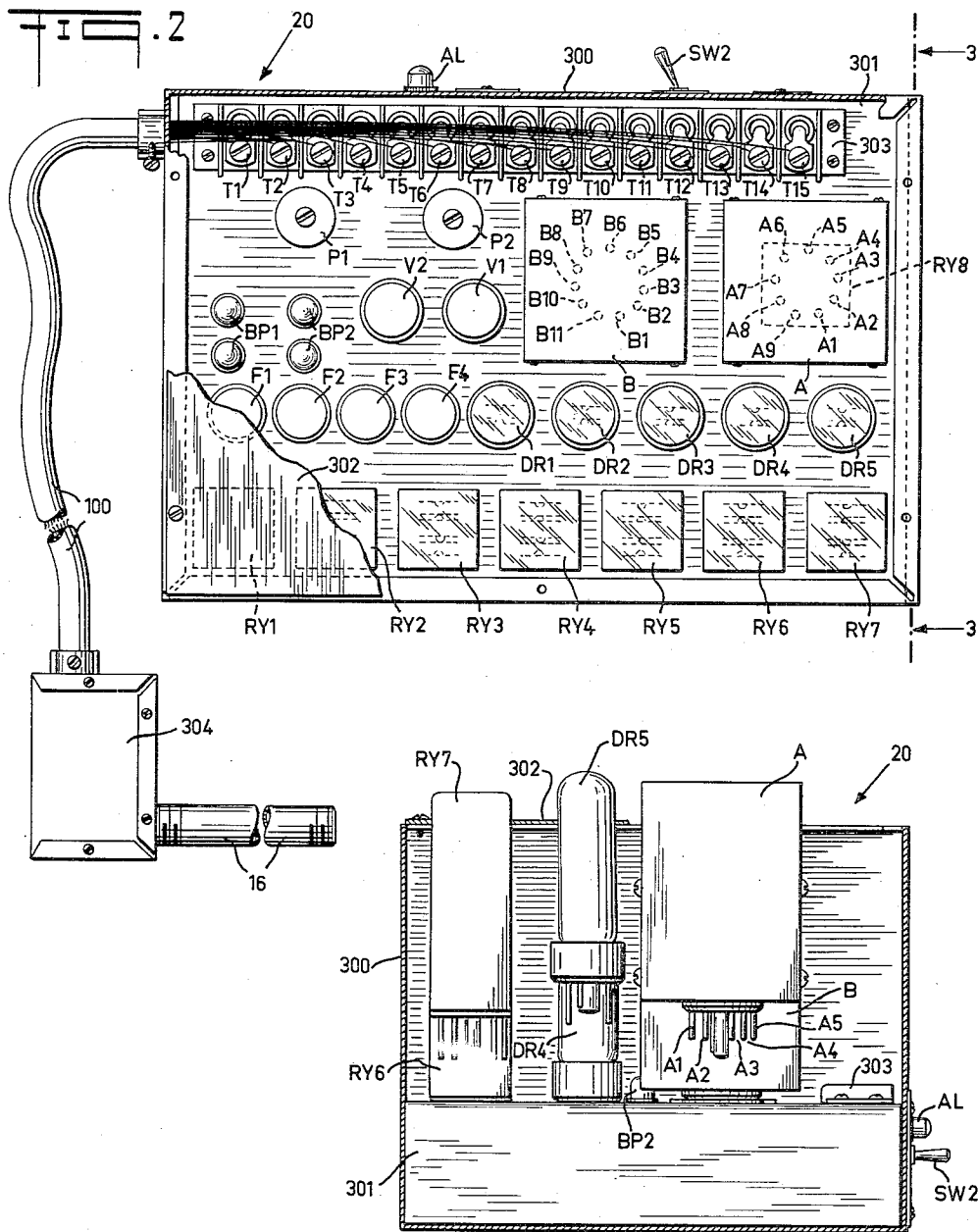


FIG. 3

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SAFETY CONTROL UNIT FOR OIL BURNERS AND THE LIKE

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Application April 12, 1956, Serial No. 577,727

13 Claims. (Cl. 158—28)

My present invention relates to an electrically operated safety control unit for heating systems, such as oil or gas burners.

Units of this character are known in which the initiation of various operations at predetermined intervals, such as the starting of a blower, the opening and the closing of the gas supply to a pilot nozzle, the energization of a heating coil to light the pilot flame and the opening of the main fuel supply, is controlled in invariable sequence by a timer mechanism whose performance follows a rigid cycle. With such arrangements it may happen, in the event of temporary power failure, that the timer on re-starting from an intermediate position admits fuel to the main burner without having again gone through the motions of lighting the pilot flame and testing the effectiveness of the igniter. Moreover, these known devices are generally of complex construction, offering substantial difficulties of access and disassembly when inspection and repairs are necessary.

The general object of my invention is provide a unit of the type set forth wherein the foregoing disadvantages are avoided.

More particularly, it is an object of this invention to provide a safety control unit for the purpose described which is substantially foolproof and adapted to re-set itself to starting position, in response to the operation of a simple manual switch, upon having given an indication of flame failure or some other alarm condition.

Another object of the present invention is to provide a unit of the aforescribed character in which most or all of the major components are in the form of readily detachable elements or sub-assemblies of the plug-in type, thereby facilitating individual testing and replacement of parts.

The invention, in accordance with one of its features, provides a system of cascade-connected relays including several delay relays having operating and/or release times of the order of tens of seconds; these latter relays may be of the thermal type and their delay times preferably range between about ten or fifteen and forty-five seconds. When all the relays are properly actuated, in response to closure of a conventional limit switch at the controlled heating system, they cause the system to be stepped through its normal operating cycle by opening and closing the various control circuits at predetermined intervals. There is further provided a photoelectric scanner which, in a manner known per se, ascertains the presence or absence of a flame and interrupts the normal sequence if the pilot or the main burner fails to light, causing an alarm to be given in such event. Such alarm will also be given if, for any reason whatever, certain relay contacts are not properly actuated within the time intervals measured by the delay relays.

According to another feature of the invention, each relay is individually enclosed in a sealed envelope having contact pins projecting therefrom which serve to connect the windings, armatures and contacts thereof to the corresponding leads. These envelopes, which are preferably

transparent, minimize the influence of atmospheric conditions upon the performance of the relays and also prevent malicious or accidental tampering with the connections. In a preferred embodiment there is also provided a separately detachable sub-assembly containing a network of fixed resistors and condensers associated with an amplifier circuit controlled by the flame scanner.

The invention will be further described with reference to the accompanying drawing in which:

Fig. 1 is a circuit diagram showing the various elements of a unit according to the invention and also the principal components of a heating system controlled by it;

Fig. 2 is a top plan view of a physical embodiment of the unit shown diagrammatically in Fig. 1; and

Fig. 3 is a sectional view taken on the line 3—3 of Fig. 2.

In Fig. 1 there is shown a conventional heating system comprising a boiler 10, one or more burners 11 supplied with fuel by a pump 12, a blower 13, a pilot nozzle 14 connected to a source of fuel (e. g. gas), not shown, and adapted to be lit by an igniter 15, and a photoelectric scanner 16 trained upon the burner 11 and the pilot nozzle 14 so as to receive light from any flame appearing thereon.

A source AC of alternating current, which may be the usual utility mains, is connected via a high-voltage conductor AC1 and a grounded conductor AC2, over circuits to be described, to various auxiliary electrical components of the system associated with boiler 10. These components include a motor M1 driving the blower 13, a draft switch DS closed by the air stream when this blower is operated, a motor M2 driving the pump 12, a pilot-valve solenoid S1 in the fuel supply line to nozzle 14, a main-valve solenoid S2 in the fuel supply line for burner 13, a pair of windings WL, WR associated with a modulator 18 which controls a throttle 17 in the same line, a heating coil HC forming part of igniter 15, and a photocell PH associated with the boiler 10. A transformer TR1 serves for the energization of either the left-hand winding WL of modulator 18 by way of a homing strip HL, whereby the modulator is rotated counterclockwise in a sense tending to bring throttle 17 to its wide-open position, or its right-hand winding WR by way of a homing strip HR, which moves it clockwise to close throttle 17 down to its minimum opening. The boiler 10 is provided in known manner with an automatic signaling device such as a limit switch LS which closes whenever the boiler demands more heat, e. g. in response to a drop in steam pressure therewithin. A normally closed switch SW1 is inserted in lead AC1.

The control unit 20, embodying the present invention, comprises a strip of fifteen terminals designated T1 through T15. All the external connections to the unit are made to these terminals. These external connections are represented by fifteen leads respectively connected to terminals T1 through T15 and numbered, in order, 101 through 115. Lead 101 connects terminal T1 to the high-voltage conductor AC1 of source AC and, via a load resistor RL1, to one end of the primary winding of transformer TR1.

Lead 102 connects terminal T2 to the grounded conductor AC2 of the same source AC and also extends to one input terminal of an alarm device here shown as a bell AB as well as to input terminals of solenoids S1, S2, motors M1, M2 and heating coil HC. Leads 103 and 104 connect terminals T3 and T4 across limit switch LS, lead 105 also continuing to one contact of draft switch DS whose other contact is connected to terminal T5 via lead 106. Lead 106 connects terminal T6 to the high-voltage side of motor M1. Lead 107 connects the second end of the primary of transformer TR1 to terminal T7. Lead 108 extends from terminal T8 to the

high-voltage inputs of solenoid S1 and heating coil HC. Lead 109 similarly extends from terminal T9 to the inputs of solenoid S2 and motor M2. Lead 110 ties terminal T10 to an extremity of the secondary winding of transformer TR1 whose other extremity is joined to the common terminal of windings WL and WR of modulator 18. Leads 111 and 112 connect homing strips HR and HL, respectively, to terminals T11 and T12. Lead 113 extends from terminal T13 to the high-voltage side of alarm device AB. Leads 114 and 115 form part of a test circuit connecting terminals T14 and T15 across the photocell PH.

The control unit 20 comprises two sub-assemblies A and B each enclosed within a metallic shield can illustrated in dotted lines. Sub-assembly A is provided with nine terminal pins designated A1 through A9; sub-assembly B is similarly provided with eleven terminal pins designated B1 through B11. Other principal elements of unit 20 include a vacuum tube V1 comprising two triodes in a common envelope; a thyratron tube V2; an alarm device illustrated as a lamp AL; a step-down transformer TR2; five delay relays DR1 through DR5, each with a heating coil and a contact arm illustrated in dotted lines; and eight relays RY1 through RY8 of which the last one, relay RY8, forms part of sub-assembly A along with two rectifiers RE1 and RE2. Sub-assembly B contains a network of resistors R1 through R11 and condensers C1 through C4 which may have the specific values indicated on the drawing.

The internal connection to terminals T1 through T15 are represented by fifteen leads designated 201 through 215, respectively. Lead 201 contains a fuse F1 and joins lead 203 extending through a back contact and the left-hand armature of principal relay RY1 to one extremity of the primary winding of transformer TR2 by way of an associated load resistor RL2. Lead 202, representing the ground bus bar of the unit, is connected to the opposite extremity of the primary winding and to one extremity of the secondary winding of transformer TR2, to one end of the heating coil of each delay relay DR1 through DR5, to one end of the windings of relays RY1, RY2, RY3, RY4, RY5, RY6 and also, via pin A3, of relay RY8, and to the right-hand grid of tube V1; this lead also grounds the shield cans of sub-assemblies A and B by way of terminal pins A9 and B4, respectively.

Lead 204 connects terminal T4, by way of a manual reset switch SW2, to the contact arms of delay relays DR1 and DR2, to the ungrounded end of the winding of principal relay RY1, to a back contact associated with the left-hand armature of this latter relay and to a front contact of relay RY4; this lead then continues via a fuse F2 to pin A7. Also connected to lead 204, via a fuse F3, are the sole armature of relay RY3, the right-hand armature of relay RY5 and the left-hand armature of relay RY6. Lead 205 extends from terminal T5 to the contact arm of delay relay DR4 whose make contact is connected to the ungrounded terminal of the winding of relay RY5. Lead 206 connects terminal T6 to the front contact of relay RY3. Lead 207 links terminal T7 with the armature of relay RY4. Leads 208 and 209 connect terminals T8 and T9 to the front contacts associated with the right-hand armature of relay RY5 and with the left-hand armature of relay RY6, respectively. Leads 210, 211 and 212 extend from their associated terminals to the right-hand armature of relay RY6, to the back contact of the left-hand armature of relay RY5 and to the back contact of the right-hand armature of relay RY6, respectively. Lead 213 completes the circuit for alarm lamp AL and also extends to the back contact of relay RY8 via terminal pin A1. Lead 214 extends from terminal T14 to pin B10. Lead 215 connects terminal T15 to pin B8 and also to the left-hand grid of tube V1.

The other terminal of the secondary winding of transformer TR2 is connected to a potentiometer P1 whose

slider is tied to a lead 216 representing the live low-voltage bus bar of unit 20. The proportioning of transformer TR2 and the adjustment of potentiometer P1 are preferably such that, given an input voltage of the order of 110 volts at the mains AC2, the *r-m-s* voltage difference between bus bars 202 and 216 will be about 6 volts. These two voltages may be read directly by means of respective voltmeters HV and LV adapted to be connected to a pair of high-voltage binding posts BP1 and a pair of low-voltage binding posts BP2, respectively; binding posts BP1 are connected across the primary of transformer TR2, binding posts BP2 being connected between bus bars 202 and 216. The heating filaments of both triodes of vacuum tube V1 and of gas-filled tube V2 are also connected across bus bars 202 and 216, being thus permanently energized as long as switch SW2 is closed.

Other important connections within unit 20 include a conductor 217, containing a fuse F4 and extending from the right-hand armature of relay RY7 to pin A4; a conductor 218, joining the front contact associated with the left-hand armature of that relay to the contact arm of delay relay DR5 and also to the other end of its heating coil; a conductor 219, linking the left-hand front contact of relay RY2 with the corresponding contact of relay RY7; and a conductor 220, extending from the plates of both triodes of tube V1 to terminal pins A5 and B2. A potentiometer P2, bridged across terminal pins B7 and B11, has its slider connected to the cathode of thyratron V2 whose plate is connected to the high-voltage terminal of the primary of transformer TR2 by way of the winding of relay RY7 and whose grid is connected via a lead 221 to pin B9; relay RY7 is slightly slow-releasing to hold up during negative half-cycles of the alternating current applied to tube V2. The winding of relay RY8 is connected between pins A3 and A4, in series with rectifier RE1, and also in shunt with condenser C2 by means of a conductor 222 extending between pins A6 and B5; the armature of this relay is linked by a conductor 223, tied to pin A8, to the right-hand front contact of relay RY1.

It will be noted that resistors R1—R6 form part of a network between ground bus bar 202, on the one hand, and the cathode leads of the two triodes of tube V1, on the other hand, which extend to pins B3 and B6, respectively. Resistor R6 is common to both cathode circuits and inserted between grounded pin B1 and the junction of resistors R4 and R5; a large balancing resistor R3 is connected between the junction of resistors R1 and R4, forming part of the cathode resistance of the right-hand triode, and the junction of resistors R2 and R5 which form part of the cathode resistance of the left-hand triode. The arrangement is symmetrical, resistors R1 and R4 being of the same magnitude as resistors R2 and R5, respectively.

The plates of tube V1 are effectively grounded for alternating current by shunt condenser C1, bridged across pins B1 and B2, which serves to smooth the pulsating direct current delivered to these plates from high-voltage lead 204 (upon closure of switches SW2 and LS) via conductor 219, pin A7, rectifier RE2, pin A5 and conductor 220. The latter conductor is also connected to the high-voltage side of potentiometer P2 by way of pin B2, resistors R10 and R11 in series, pin B11 and a lead 224. The low-voltage side of the potentiometer is continued to ground by way of a lead 225, pin B7, resistor R7 and pin B1. Resistor R8 and condenser C3, connected in parallel, represent a network of large time constant inserted between pin B8, which is tied to the left-hand grid of tube V1, and the junction of that tube's cathode resistors R2, R5. Resistor R9 connects this same junction, via pin B9 and lead 221, to the grid of tube V2. Condenser C2, bridged across pins B1 and B5, shunts the winding of alarm relay RY8 which is connected between ground on pin A3 and high voltage on lead 204 through

5

rectifier RE1, pin A4, lead 217, the right-hand back armature and back contact of flame-failure relay RY7, and the contact arm of delay relay DR1. Condenser C4 represents an additional smoothing capacitor inserted between ground and the junction of resistors R10 and R11, this junction being joined to the left-hand grid of tube V1 through pin B10, lead 214, terminal T14, lead 114, photocell PH, lead 115, terminal T15, lead 215.

Other connections will become apparent from the ensuing description of the mode of operation of the present system.

The contacts of all the relays RY1-RY8 and DR1-DR5 have been illustrated in the position which they occupy when switch SW1 is closed and switch SW2 is open, as shown. Under these circumstances transformer TR2 is energized from lead 203 via the left-hand armature and back contact of relay RY1, causing the normal operating voltage to appear across bus bars 202 and 216. This energizes the heating coil of delay relay DR1 via right-hand armature and back contact of principal relay RY1, the heating coil of delay relay DR4 via left-hand armature and back contact of flame-failure relay RY7, and the heating coil of delay relay DR3 via right-hand armature and back contact of auxiliary relay RY2. It will be noted that the contact arm of relay DR3 makes and that the contact arms of all the other delay relays break when the associated heating coils are deenergized; in the quiescent state referred to, therefore, the contact of delay relays DR1 and DR4 are closed while those of the other three delay relays are open. The filaments of tubes V1 and V2 are also heated in this condition.

When the manual switch SW2 is closed, the unit is placed in a state of preparedness in which it can respond to closure and opening of the limit switch LS. When this limit switch closes, principal relay RY1 is energized in a starting circuit extending from ground on lead 102, terminal T2 and bus bar 202 through its winding, switch SW2, terminal T4, lead 104, switch LS, lead 103, terminal T3, lead 201, switch SW1 to lead 101 and source AC. Relay RY1, in attracting its left-hand armature, transfers the energizing circuit for the primary winding of transformer TR2 from lead 203 to lead 204, thereby placing this circuit under the direct control of series-connected switches SW2 and LS. This is desirable in that it provides a brief interval insuring the positive deionization of tube V2, the reapplication of potential to the plate of that tube occurring only after the completion of a circuit from potentiometer P2 to high-voltage lead 204 via lead 224, pin B11, resistors R11 and R10, pin B2, lead 220, pin A5, rectifier RE2, pin A7. At the same time an interim operating circuit for alarm relay RY8 is closed from lead 204 through the closed contacts of delay relay DR1, right-hand back contact and armature of flame-failure relay RY7, lead 217, pin A4, rectifier RE1, winding of alarm relay RY8, pin A3 to ground on bus bar 202. Relay RY8 attracts its armature and at its back contact disconnects lead 223 from the alarm circuit including lamp AL, bell AB and conductors 213, 113.

Meanwhile, principal relay RY1 at its right-hand armature has broken the heating circuit of relay DR1 whose delay period is assumed to be thirty seconds, as indicated. The right-hand armature of relay RY1 also extends the potential from bus bar 216 over its front contact to conductor 223 and, via the armature and front contact of relay RY8, to pin A2 and the winding of auxiliary relay RY2 which is thus energized. Current also passes through the heating coil of relay DR2, connected in parallel with the winding of relay RY2, whose delay time has been indicated to be fifteen seconds.

The operation of relay RY2 reverses its right-hand armature and disconnects heating current from relay DR3 whose delay time has also been assumed to be fifteen seconds. The ground on that armature is now applied, via its front contact, to the winding of relay RY3 which attracts its armature and interconnects leads 204 and

6

206, thereby completing the operating circuit for motor M1 from source AC via leads 106 and 102. Motor M1 starts up and actuates the blower 13.

Relay RY4, having its winding connected in parallel with that of relay RY3, operates in a circuit extending from bus bar 216 via the right-hand armature and front contact of relay RY2 to bus bar 202. Relay RY4 closes an energizing circuit for transformer TR1 which can be traced from the right-hand end of its primary winding over conductor 107, terminal T7, conductor 207, armature and front contact of relay RY4, lead 204, switch SW2, terminal T4, lead 104, switch LS, lead 103, terminal T3, lead 203, lead 201, switch SW1, lead AC1, source AC, lead AC2, lead 102 through load resistor RL1 back to the left-hand end of this winding. If at this time the modulator 18 is in any position other than the one illustrated, a circuit extends from the secondary of transformer TR1 via lead 110, terminal T10, lead 210, right-hand armature and back contact of relay RY6, lead 212, terminal T12, lead 112, homing strip HR and associated contact brush, winding WR back to the secondary, whereby the modulator is energized for clockwise rotation in a sense tending to close the throttle 17. When this throttle reaches its position of minimum opening, the contact brush steps off homing strip HR and the modulator stops.

Meanwhile, the forced circulation of air resulting from the operation of blower 13 has closed draft switch SW so as to complete an energizing circuit for relay RY5 by connecting conductor 105 to high-voltage lead 103, this circuit continuing by way of terminal T5, lead 205, closed contacts of delay relay DR4 which is still in a heated condition, winding of relay RY5 to ground on bus bar 202. Relay RY5, at its right-hand armature, interconnects leads 204 and 208, thereby energizing the heating coil HC and the pilot-valve solenoid S1 in a circuit extending from source AC over conductors 102 and 108 to terminal T8. If the igniter 15 operates properly, a flame will spring up at nozzle 14 and will excite photocell PH.

Fifteen seconds after the operation of auxiliary relay RY2, thermal relay DR3 closes its contacts and completes an operating circuit independent of relays RY1 and RY2 for relays RY3 and RY4, thereby insuring continued operation of blower 13 and modulator 18 after limit switch LS opens.

Within about a second after the closure of switch LS had applied high voltage to lead 204 and, thereby, to the plates of tube V1 via lead 220, considering the large time constant of the network R8, C3 connected to the left-hand grid of that tube, the latter will have reached a steady-state condition in which its left-hand grid is maintained slightly more positive than its grounded right-hand grid and both tube sections are conducting. In this condition the grid of thyatron V2, tied to the cathode circuit of the left-hand triode at the junction of resistors R2 and R5, is held sufficiently negative to prevent the ionization of tube V2.

When the scanner 16 senses a flame, the test circuit extending through photocell PH unbalances the tube V1 by impressing positive potential from the junction of resistors R10 and R11 upon the left-hand grid of that tube; the circuit therefor extends from said junction to pin B10, thence via lead 214, terminal T14 and lead 114 to photocell PH and over lead 115, terminal T15 and lead 215 to the left-hand grid of tube V1. Part of the additional current now drawn by the left-hand triode flows through resistors R3 and R4, thereby raising the potential of the right-hand cathode and reducing the current through that section; this, in turn, lowers the voltage drop through common cathode resistor R6 and enables the left-hand section to carry still more current. This operation of the high-sensitivity amplifier V1 drives the grid of thyatron V2 positive and causes this tube to

conduct in series with the winding of relay RY7, thus operating the latter.

The reversal of the left-hand armature of relay RY7 transfers the potential of bus bar 216 from the heating coil of relay DR4, assumed to have a cooling-off period of forty-five seconds, to that of relay DR5 whose delay period is fifteen seconds. At its right-hand armature the relay RY7 disconnects the operating lead 217 of relay RY8 from the contacts of delay relay DR1 and connects it to lead 219 which is energized from lead 204 via contacts of relays DR2 and RY2. Thus, when delay relay DR1 opens its contacts thirty seconds after the operation of relay RY1, the main energizing circuit of relay RY8 is closed in lieu of its aforementioned interim circuit whereby this relay remains operated and the alarm devices AL and AB are not actuated.

After a further fifteen-second period, relay DR5 closes its contacts and operates relay RY6 in parallel with its own heating coil. The left-hand armature of relay RY6, in making its front contact, interconnects leads 204 and 209, thereby actuating the main-valve solenoid S2 and the motor M2, connected to fuel pump 12, in a circuit extending from source AC via leads 102 and 109 to terminal T9. At the same time the relay RY6, at its right-hand armature, opens the connection between leads 210, 211 and prepares an energizing circuit for modulator winding WL by connecting lead 210 to the left-hand armature of relay RY5 which is still operated. Fuel is now delivered at a relatively low rate to the burner 11, to be ignited by the flame on pilot nozzle 14.

Forty-five seconds after the operation of relay RY7 has broken the heating circuit of delay relay DR4, this latter relay opens its contacts and de-energizes relay RY5. The resulting removal of potential from lead 208 de-activates the igniter 15 and shuts the fuel supply to nozzle 14. If the burner 11 has been properly lighted, photocell PH continues to maintain relay RY7 operated, thereby insuring the continued energization of relays RY2, RY3, RY4, RY6 and RY8. Relay RY5, in releasing, now completes the aforementioned circuit for the energization of modulator winding WL, this circuit extending from the left-hand end of the secondary of transformer TR1 through winding WL over the contact brush associated with homing strip HL, conductor 111, terminal T11, lead 211, back contact and left-hand armature of relay RY5, front contact and right-hand armature of relay RY6, lead 210, terminal T10, lead 110 to the right-hand end of the secondary. This causes the modulator 18 to rotate counterclockwise until the contact brush steps off homing strip HL in the wide-open position of throttle 17 in which fuel is reaching the burner 11 at a high rate. The system remains in this condition as long as the limit switch LS and the manual switch SW2 are closed.

When the needs of the boiler 10 have been satisfied, the limit switch LS opens and removes potential from lead 204. Relay RY1 releases and reconnects the upper terminal of the primary of transformer TR2 to lead 203, the switch-over interval serving to de-ionize tube V2 whose cathode has been driven more negative by the removal of positive voltage from potentiometer lead 224. Relays RY2, RY6, RY7 and RY8 are de-energized; the release of relay RY8, however, causes no alarm at this time since the circuit for the operation of devices AL and AB has been broken at the right-hand armature of relay RY1. The release of relays RY1 and RY7 reconnects heating current to delay relays DR1 and DR4 but the subsequent reclosure of their contacts is without immediate effect. The release of relay RY6 recloses the previously traced energizing circuit for winding WR and narrows the opening of throttle 17. The release of relay RY2 re-energizes the heating coil of relay DR3 which at the end of its delay interval breaks the operating circuit of relays RY3 and RY4, thus enabling the resetting of modulator 18 and maintaining blower motor M1 op-

erated for fifteen seconds after the fuel supply to burner 11 has been discontinued. The removal of heating current from delay relays DR2 and DR5 by relays RY8 and RY7, respectively, restores the system to its initial state of preparedness.

If any of relays RY2, RY7, RY8 had failed for any reason to operate at the appointed time, the progress of the switching operations would have been interrupted and an alarm condition established.

If no flame had appeared by the time when relay DR1 opened its contacts, the non-operation of relay RY7 would have released relay RY8 and caused it to operate the alarm devices AL and AB. Relays RY5 and RY6 would not have operated and relay RY2 would have released, causing the re-energization of delay relay DR3 so as to de-activate relays RY3, RY4 and de-energize blower motor M1 and transformer TR1 after an interval of fifteen seconds. Similarly, if flame failure occurs at any time after thermal relay DR1 has cooled with the limit switch LS closed, relays RY7 and RY8 in releasing open the operating circuits of relays RY2, RY5 (if operated), RY6 and, eventually, RY3 and RY4, leaving relay RY1 as the sole quick-acting relay operated. This alarm condition can be altered only by breaking the energizing circuit of relay RY1, as by opening the manual reset switch SW2, which returns the system to its quiescent state. It should be noted that the alarm devices AB and AL will remain unoperated only if an interval of at least thirty seconds is allowed to elapse before switch SW2 is re-closed, this being the time necessary for relay DR1 to heat up and to prepare the initial energizing circuit for relay RY8. If draft switch DS had remained open, indicating failure of motor M1 or blower 13, relay RY 5 would have remained unoperated and the eventual release of flame-failure relay RY7, due to non-activation of igniter 15, would have completed the alarm circuit of relay RY8. It should be observed that, in the system just described, all thermal relays are energized from the low-voltage bus bar 216. Since some of these relays remain operated over long periods of time, this arrangement represents a great saving in energy. Inasmuch as some deviations from the nominal operating intervals of the various delay relays may be tolerated, minor fluctuations in line voltage will be without adverse effect; in the presence of larger voltage differences the proper potential for bus bar 216 may be established with the aid of potentiometer P1. Potentiometer P2 serves to adjust the photoelectric scanning system PH, V2 to the desired degree of sensitivity, taking into consideration that the scanner should respond to an actual flame but not to the red and infrared afterglow of the burner chamber.

Reference is now made to Figs. 2 and 3 for a description of a preferred physical embodiment of the control unit according to the invention. The unit 20 shown in these figures comprises a chassis 300 whose interior is subdivided by a base 301 into an upper and a lower compartment. The upper compartment, adapted to be closed by a cover 302, houses the terminals T1—T15 mounted on a terminal strip 303 on base 301; the two sub-assemblies A and B, detachably secured to corresponding sockets on base 301 by their respective terminal pins A1—A9 and B1—B11 as particularly illustrated for sub-assembly A in Fig. 3; the delay relays DR1—DR5, detachably secured to other sockets on the base by means of similar pins as particularly illustrated for relay DR5 in Fig. 3; the high-speed relay RY1—RY7, detachably secured to the base in like manner as particularly illustrated for relay RY7 in Fig. 3 supplemented by relay RY8 in sub-assembly A; the tubes V1 and V2, mounted in analogous fashion on base 301 by means of terminal pins (not shown) as is well known per se; and fuses F1—F4, potentiometers P1, P2, as well as voltmeter posts BP1, BP2, all readily accessible upon removal of cover 302. All the quick-acting and delay relays are housed in transparent shells enabling (in the case of relay

RY8, after removal from metal can A) ready ascertainment of the condition of their respective contacts.

The various internal connections of the unit, not further illustrated in Figs. 2 and 3, are disposed within the lower compartment underneath base 301 and may be represented by printed circuits. The outer connections, represented by conductors 101—115 (cf. Fig. 1), are led out of housing 300 within a cable 100 terminating at a junction box 304 to which scanner tube 16 is threaded-ly attached and which also houses the photocell pH (not shown in Figs. 2 and 3). Alarm lamp AL and manual switch SW2 are externally mounted on housing 300.

The invention is, of course, not limited to the specific embodiment described and illustrated but is susceptible of various modifications and adaptations without departing from the spirit and scope of the appended claims. Thus, the arrangement herein disclosed may be used in combination with any controlled system whose operation is initiated by a signal from such system (as by means of limit switch LS) and which is adapted to co-operate with a monitoring device (such as the scanner 16 or the draft switch DS) indicating by its response the proper activation of the system.

I claim:

1. A safety control unit for a heating system provided with a burner, a pilot nozzle adjacent said burner, igniter means adjacent said pilot nozzle, first valve means for admitting fuel to said pilot nozzle, second valve means for admitting fuel to said burner, photoelectric scanning means positioned to be excited in the lighted condition of either said pilot nozzle or said burner, and switch means adapted to be closed in a condition of said system calling for the lighting of said burner; said unit comprising a housing, conductors extending from said housing for connection to said system and forming part of a starting circuit adapted to be closed by operation of said switch means, a test circuit adapted to be closed by operation of said scanning means, a first operating circuit closable to energize said first valve means and igniter means and a second operating circuit closable to energize said second valve means, amplifier means having input connections in said test circuit, a plurality of quick-acting relays provided with respective sets of contacts, said relays including a principal relay connected in said starting circuit, a flame-failure relay connected to the output of said amplifier means and an alarm relay connected to be controlled by the contacts of said flame-failure relay, said alarm relay having an unoperated condition in which its contacts prevent completion of either of said operating circuits, contacts of said flame-failure relay being connected to control said alarm relay so as to close a main energizing circuit for the latter in the excited condition of said scanning means, a plurality of thermal relays provided with respective sets of contacts and having delay periods of the order of tens of seconds, means including contacts of certain of said thermal relays and of said principal and flame-failure relays for sequentially closing said first and second operating circuits upon operation of said switch means and of said scanning means, respectively, means including contacts of other of said thermal relays for closing an interim energizing circuit for said alarm relay for a limited interval following closure of said first operating circuit and before excitation of said scanning means, and an alarm circuit closable by contacts of said principal relay and of said alarm relay for giving an alarm in an operated condition of said principal relay coinciding with the unoperated condition of said alarm relay.

2. A unit according to claim 1, for use with a heating system including blower means, wherein said conductors define a further operating circuit closable to energize said blower means, said unit being provided with means including contacts of certain of said quick-acting relays and of said delay relays for closing said further operating

circuit ahead of said first operating circuit and for keeping said further operating circuit closed for a limited interval following opening of said first and second operating circuits.

3. A unit according to claim 1, for use with a heating system including throttle means for changing the rate of fuel delivery to said burner, wherein said conductors form part of two alternative operating circuits closable to energize said throttle means in a manner corresponding to low-rate and high-rate fuel delivery, respectively, said unit being provided with means including contacts of certain of said quick-acting relays and of said delay relays for closing first said low-rate operating circuit and subsequently said high-rate operating circuit.

4. A unit according to claim 1, wherein said quick-acting relays include an auxiliary relay controlled by contacts of said principal relay and of said alarm relay, said auxiliary relay having contacts connected to actuate other of said quick-acting relays upon being itself operated subsequently to the operation of said principal and alarm relays.

5. A unit according to claim 1, adapted to be operated by a source of high-voltage alternating current, further comprising step-down transformer means having a primary and a secondary winding, first circuit means for connecting said primary winding across said source, and second circuit means for energizing said thermal relays from said secondary winding under the control of contacts of said principal and flame-failure relays.

6. A unit according to claim 5, wherein said first circuit means includes contacts of said principal relay adapted to connect said primary winding across said source in series with said switch means upon operation of said principal relay.

7. A unit according to claim 1, comprising a manual switch in said starting circuit operable to de-activate said principal relay upon closure of said alarm circuit.

8. A unit according to claim 1, wherein said housing is provided with a base having sockets for removably receiving said quick-acting and thermal relays as well as said amplifier means, each of said relays being provided with a set of terminal pins fitting into a respective one of said sockets.

9. A unit according to claim 8, wherein each of said relays is provided with an individual envelope.

10. A unit according to claim 8, further comprising rectifier means connected in series with said alarm relay, said alarm relay and said rectifier means together forming part of a detachable sub-assembly receivable in one of said sockets.

11. A unit according to claim 8, comprising a network of resistors and capacitances connected in said input connections of said amplifier means, said resistors and capacitances forming part of a detachable sub-assembly receivable in one of said sockets.

12. A unit according to claim 8, wherein said base is provided with a set of terminals each connected to a respective one of said conductors.

13. A unit according to claim 8, further comprising a lamp and a switch mounted on said housing, said lamp being connected to be energized by contacts of said principal and alarm relays in the operated condition of said principal relay with said alarm relay simultaneously unoperated, said switch being inserted in said starting circuit.

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