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Ishida

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[54] **HIGH VOLTAGE PULSE GENERATING APPARATUS**

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[52] **U.S. Cl.** **317/96,** 317/151, 431/29

[51] **Int. Cl.** **F23q 3/00**

[58] **Field of Search** ... 317/96, DIG. 8, 151; 431/29, 431/31

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[57] **ABSTRACT**

A combustion control device for controlling the combustion of a liquid fuel such as petroleum fuel. The device incorporates a capacitor-discharging ignition, a prepurging operation, a post-ignition extending operation and safety means for preventing accidents which may occur due to system faults.

7 Claims, 5 Drawing Figures

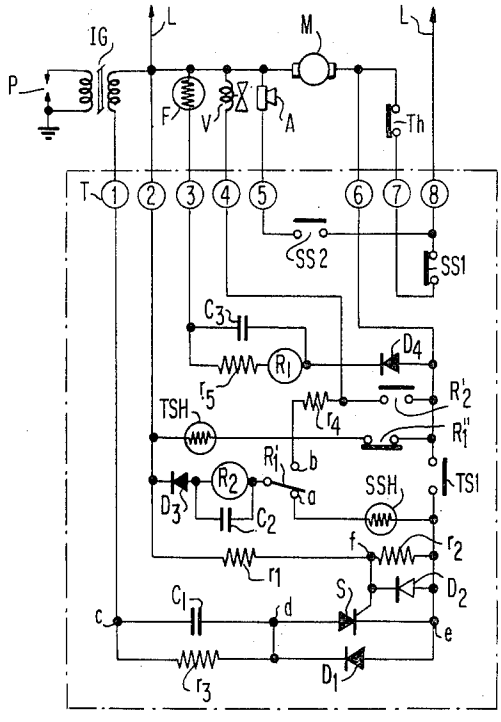


FIG. 1

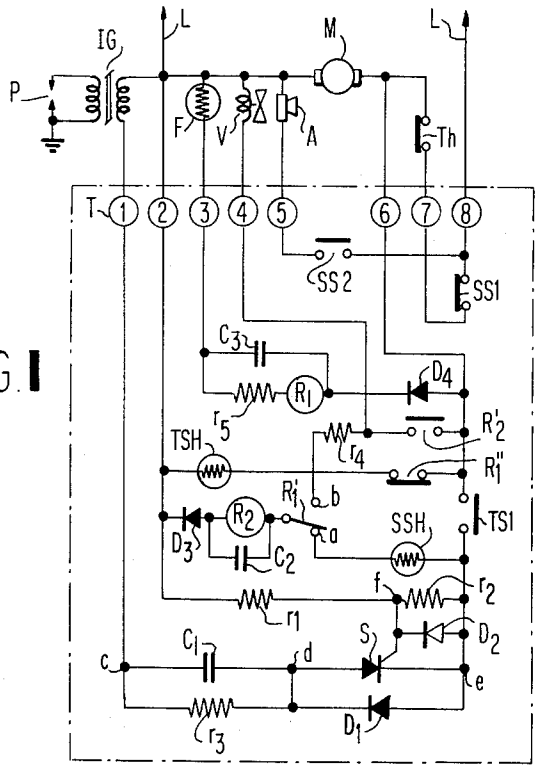


FIG. 2

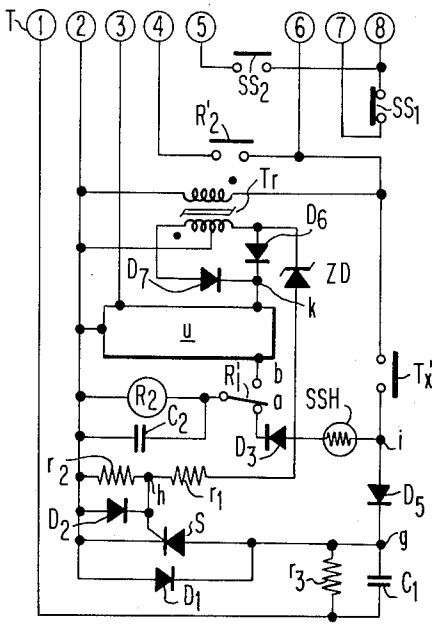
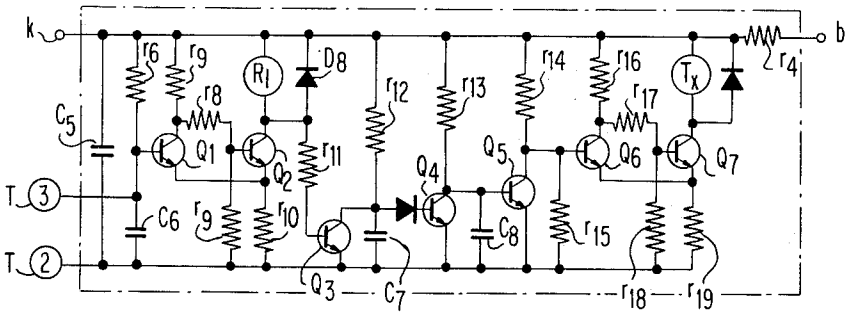


FIG. 3



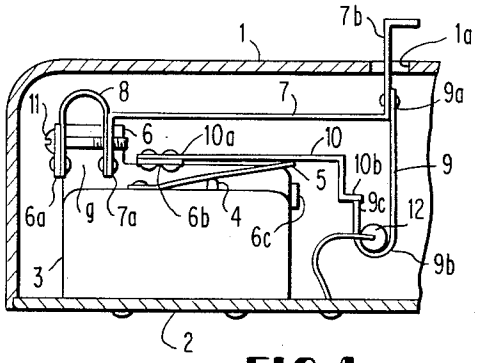


FIG. 4a

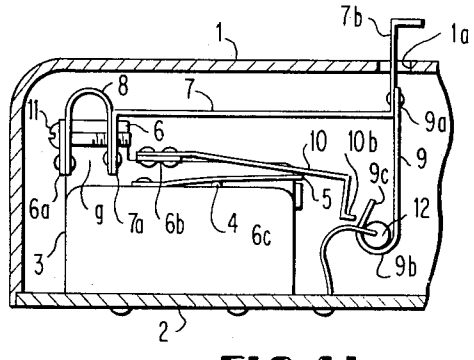


FIG. 4b

HIGH VOLTAGE PULSE GENERATING APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a combustion control device for use with a burner, and more particularly to a control device incorporating a prepurge operation and a safety monitoring circuit.

2. Description of the Prior Art

Heretofore, in an electric ignition system for a burner utilizing sprayed fuel, a commercial AC power supply, such as 60 Hz, 115 volts connected by a step-up transformer such as 7KV secondary output, is used. Several electromagnetic relays such as a fuel valve operation relay, and safety means such as a temperature switch are also used in the system. The systems are complicated, and are located in high temperature environments with the result that the endurable life is short and their reliability is low.

Therefore, it is an object of the present invention to provide a highly reliable fuel control device which is simple in construction and compact because of solid-state components.

SUMMARY OF THE INVENTION

The combustion control device of the present invention comprises means for controlling the fuel supply and a transformer for supplying ignition energy to the fuel. The device further includes means for detecting a flame to confirm the ignition of the fuel, means for determining the continuation of the operation during a predetermined time, means for detecting the continuation of the operation beyond a predetermined time, and means for rapidly discharging a capacitor through the transformer.

Other objects, features and advantages of the present invention will become apparent from the following description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic diagram of the various devices combined with one embodiment of the fuel control device of this invention.

FIG. 2 is a block diagram of a fuel control device of another embodiment of the present invention.

FIG. 3 shows the details of the relay energizing control circuit of the relay in FIG. 2.

FIGS. 4*a* and 4*b* are side sectional views of the adjustable safety switch utilized for the fuel control device of this invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In FIG. 1, a plurality of terminals T_1 to T_8 are provided in the control device surround by the broken line. The terminal T_1 is connected through the primary winding of an ignition transformer IG to one of the terminals of AC power supply, the terminal T_2 is directly connected to the AC power supply, the terminal T_3 is connected to a flame detector F such as a CdS element, and the terminal T_4 is connected to a fuel valve operation solenoid valve V. The terminal T_5 is connected to a warning device A and the terminal T_6 is connected to a blower and hydraulic pump drive motor M. The terminal T_7 is connected through a normally closed

contact Th of a thermostat to the terminal T_6. The terminal T_8 is connected to the other terminal of the AC power supply. A spark discharge gap P for fuel ignition is connected to the secondary winding of the transformer IG. The terminal T_5 is connected through the normally open contact SS2 of a safety switch SS to the terminal T_8. The terminal T_7 is connected through a normally closed contact of the safety switch SS to the terminal T_8. The terminal T_3 is connected through a series circuit of a resistor r_5, energizing coil R_1 of a first electromagnetic relay and diode D_4 to the terminal T_6. The resistor r_5 and the energizing coil R_1 are shunted by a smoothing capacitor C_3. The terminal T_2 is connected through a heater resistor TSH of a thermal switch TS and the normally closed contact R''_1 of the first electromagnetic relay to the terminal T_6. The terminal T_2 is connected through a series circuit of diode D_3, energizing coil R_2 of the second electromagnetic relay, the normally closed contact a of the switching contact R'_1 of the first electromagnetic relay, the heater resistor SSH of the safety switch SS, and the normally open contact TS1 of the thermal switch TS to the terminal T_6.

The energizing coil R_2 is shunted by the smoothing capacitor C_2. The normally open contact *b* of the switching contact R'_1 is connected through a resistor r_4 to the terminal T_4. The terminal T_4 is connected through the normally open contact R'_2 of the second electromagnetic relay to the terminal T_6. The terminal T_2 is further connected through the series connection of the resistors r_1 and r_2 to the contact TS1 of the thermal switch. The terminal T_1 is connected to a main capacitor C_1 and one connecting point c of the resistor r_3 in parallel therewith. The main capacitor C_1 and the other connecting point d of the resistor r_3 are common with one connecting point of the diode D_1 connected in opposite parallel with a thyristor S. The thyristor S and the other connecting point e of the diode D_1 are connected to the connecting point TS1 of the thermal switch. The gate electrode of the thyristor S is connected to the connecting point *f* of the resistors r_1 and r_2. Further, protecting diode D_2 is connected in parallel with the resistor r_2.

Then, the operation of thus constructed control device of this invention will now be described in various cases.

At first, as normal operation, when a main switch (not shown) is closed, a line voltage is applied between the terminals T_2 and T_8. Since the contacts Th of the thermostat and the contacts SS1 of the safety switch are closed, the blower and an electric motor M for driving a hydraulic pump start the prepurging of the combustion chamber of a furnace, and the build-up of the fuel hydraulic pressure is started. Separately, after a predetermined time such as 20 seconds, the normally open contact TS1 is closed by the energization of the heater TSH of the thermal switch and heating thereof. The predetermined time is selected to complete the buildup of the hydraulic pressure and the prepurging.

A charge is stored in the main capacitor C_1 by the current flowing from the terminal T_6 through the contact TS1, diode D_1, main capacitor C_1, terminal T_1, and transformer IG to the terminal T_2, while magnetic energy is accumulated at the transformer IG. At the next half cycle of the line voltage wave, the line voltage applied between the terminals $T_2$and T_6 is shunted by

the resistors r_1 and r_2, and applied to the gate electrode of the thyristor S, so that the thyristor S is turned on. It is preferred that the phase angle of the voltage wave at this time is approximately 60° to select the values of the resistors r_1 and r_2. Immediately before the thyristor S is turned ON, the voltage corresponding to the charge stored in the capacitor C_1 and the line voltage is applied between the main electrodes of the thyristor S, and as the thyristor S is turned ON, the raised voltage is applied to the primary winding of the transformer. Therefore, in the iron core of the transformer, the magnetic flux due to the discharge of the capacitor is added to the flux corresponding to the accumulated energy and, accordingly, a voltage, raised by far greater coefficient than the ratio of the secondary winding to primary winding, is induced in the secondary coil so that sparking is generated at the gap P.

The coil R_2 of the second electromagnetic relay is energized by the current flowing from the heater SSH of the safety switch so that the contact R'_2 is closed, and a change in the strain on the thermal element (not shown) is started by the generation of the heat of the heater SSH. The fuel supply means control solenoid V is energized by the closing of the contact R'_2, and the fuel valve (not shown) is opened. Thus the sprayed fuel is ignited by the spark in the combustion chamber of the furnace.

When the flame of the combusion of the ignited fuel grows sufficiently, it is detected by the flame detector F. The flame detector is composed of photoconductive material such as CdS, and when it detects the flame, its electric resistance is abruptly lowered. Therefore, upon the detection of the flame the current flowing through coil R_1 is increased, and the coil R_1 is energized, so that the contact R'_1 is switched to the side b whereby the contact R'_2 is held closed. At the same time, the contact R''_1 is opened. The current flowing to the heater SSH of the safety switch is also cut off before the safety switch is operated. The heater TSH of the thermal switch starts cooling upon the opening of the contact R''_1, and after a short time the contact TS1 is opened, thus resetting itself. Therefore, in a short period of time after the flame has sufficiently grown, that is after proper post-ignition, the ignition circuit composed of the thyristor S, main capacitor C_1 and transformer IG return to an inoperative state. In such a state, the contact R'_1-*b* is closed. R'_2 is also closed. R''_1 is open, and the other components are as shown in FIG. 1. The motor M remains operating and the fuel valve remains open, thus continuing the normal operation.

When the water temperature or room temperature reach a predetermined level as the burner continues in normal combustion, this is detected by the thermostat, so that the contact Th is opened. Thus, the current flowing through motor M and coils R_1 and R_2 is cut off so that the combustion is stopped with the result that the system returns to the original state. When the contact Th is reclosed by the lowering of the water temperature, all above steps are repeated, and control by the thermostat is repeated.

During the above normal operation, when the flame is extinguished for any reason, the resistance of the flame detector F is increased, the current flowing through the coil R_1 is reduced, thus deenergizing the relay, so that the contacts R'_1 and R''_1 are returned to the position shown in the drawing. Since the contact TS1 is opened as shown, the coil R_2 is also deenergized, and the contact R'_2 is reset, and the fuel supply is shut off. However, since the line voltage is applied, and the contacts Th and SS1 are closed, the operation of the motor M is continued, thus purging the unburned residual fuel. The contact TS1 is closed at a predetermined time by the reenergization of the thermal switch TSH, and similar to the above, reignition is tried again. If there is no trouble, it returns to the normal operation. Heat is accumulated at a constant rate by the current flowing through the heater SSH and contacts R'_1-a and coil R_2. This heat after a predetermined time operates the safety switch SS, opening the contact SS1, and closing the contact SS2. When sufficient ignition of fuel and flame growth do not occur during the predetermined time, or even if the flame grows but it is not detected, or when complete function of the electromagnetic relay contact R'_1 is lost, the contact SS1 is opened, the operation of motor M is stopped, and the contact SS2 is closed, operating the warning device A. This safety switch is a locking device, and after the check of the oil feed system and the other components and removal of the abnormal condition, it is preferred to release the locking device manually.

Then, another embodiment shown in FIG. 2 of this invention will now be described in detail.

The device shown in FIG. 2 is basically the same as that shown in FIG. 1 except for the flame detecting circuit, and the third electromagnetic relay corresponding to the thermal switch for adjusting the sensitivity and response time shown in FIG. 1. In the device shown in FIG. 2, in order to prevent the abrupt voltage change presented when the thyristor is energized, only the energy of a half wave of the line voltage is used.

The various components connected to the terminals T_1 to T_8 outside of the control device are similar to those shown in FIG. 1; therefore, the description is omitted in FIG. 2. The primary winding of the step-down transformer Tr is connected between the terminals T_2 and T_6. The secondary winding of the transformer Tr is connected through the diodes D_6 and D_7 to a node *k*. The neutral point of the secondary winding is connected to the terminal T_2. The series connection of the main capacitor C_1, diode D_5 and normally open contact T'_x of the third electromagnetic relay is connected between the terminals T_1 and T_6. The path between the main electrodes of the thyristor S is connected between the connecting point g of the main capacitor C_1 and the diode D_5 and the terminal T_2. Further, the series connection of the resistor r_2, resistor r_1 and zener diode ZD is connected between the terminal T_2 and the secondary winding of the transformer Tr. The connecting point H of the resistors r_2 and r_1 is connected to the gate electrode of the thyristor S. The diode D_1 is in an opposite parallel with the path between the main electrodes of the thyristor S. The protecting diode D_2 is provided between the gate electrode of the thyristor S and the terminal T_2. The main capacitor C_1 is shunted with the resistor r_3.

The series connection of the energizing coil R_2 of the second electromagnetic relay, normally closed contacts R'_1-a of the first electromagnetic relay, diode D_3 and the heater resistor SSH of the safety switch SS is connected between the connecting point i of the diode D_5 and the normally open contact T'_x and the terminal T_2. The energizing coil R_2 is shunted by the smoothing capacitor C_2. The terminal T_4 is connected through the normally open contact R'_2 of the second electromag-

netic relay to the terminal T_6. The terminal T_5 is connected through the normally open contact SS2 of the safety switch to the terminal T_8. The terminal T_7 is connected through the normally closed contact SS1 of the safety switch to the terminal T_8. The flame detecting circuit and the third electromagnetic relay control circuit *u*, which will hereinafter be described, are connected to the terminals T_2 and T_3, the connecting point *k*, and the normally open contact *b* of the first electromagnetic relay.

In the flame detecting and third electromagnetic relay control circuit shown in FIG. 3, the connecting point *k* is connected through the resistor r_4 to the normally open contact *b*. In addition, the connecting point *k* is connected through the capacitor C_5 to the terminal T_2. The terminal T_2 is connected through the capacitor C_6 to the terminal T_3. The terminal T_3 is connected through the resistor r_6 to the connecting point *k*, and is also connected to the base of the transistor Q_1. The emitter of the transistor Q_1 is connected through the resistor r_{10} to the terminal T_2. The collector of the transistor Q_1 is connected through the resistor r_7 to the connecting point *k*. The collector of the transistor Q_1 is connected through the resistor r_8 to the base of the transistor Q_2, and the base is connected through the resistor r_9 to the terminal T_2. The emitter of the transistor Q_2 is connected to the emitter of the transistor Q_1, and the collector of the transistor Q_2 is connected through the energizing coil R_1 of the electro-magnetic relay to the connecting point *k*. The collector of the transistor Q_2 is connected through the diode D_8 to the connecting point *k*, and further through the resistor r_{11} to the base of the transistor Q_3. Therefore, the transistors Q_1 and Q_2 form an emitter-coupled binary or Schmitt trigger circuit together with the cooperative components. The emitter of the transistor Q_3 is connected to the terminal T_2, and the collector thereof is connected through the resistor r_{12} to the connecting point *k*. The collector of the transistor Q_3 is also connected through the diode D_{10} to the base of the transistor Q_4. The collector-emitter-path of the transistor Q_3 is shunted by the timing capacitor C_7. The emitter of the transistor Q_4 is connected to the terminal T_2. The collector of the transistor Q_4 is connected through the resistor r_{13} to the connecting point *k* and to the base of the transistor Q_5. The emitter-collector-path of the transistor Q_4 is shunted by the timing capacitor C_8. The emitter of the transistor Q_5 is connected to the terminal T_2. The collector of the transistor Q_5 is connected through the resistor r_{14} to the connecting point *k*, and to the base of the transistor Q_6. The emitter-collector path of the transistor Q_5 is shunted by the resistor r_{15}. The emitter of the transistor Q_6 is connected through the resistor r_{19} to the terminal T_2, and the collector thereof is connected through the resistor r_{16} to the connecting point *k*. The collector of the transistor Q_6 is connected through the resistor r_{17} to the base of the transistor Q_7. The base of the transistor Q_7 is connected through the resistor r_{18} to the terminal T_2, and the emitter thereof is connected to the emitter of the transistor Q_6. The collector of the transistor Q_7 is connected through the energizing coil T_x of the third electromagnetic relay to the connecting point *k*. The diode D_9 is provided in parallel with the coil T_x. Therefore, second emitter-coupled binary or Schmitt trigger circuit is formed by the transistors Q_6 and Q_7 and related components thereto. Zener diode ZD is connected between the output terminal of the transformer Tr and the resistor r_1. Diode D_5 is connected in series with the main capacitor C_1.

The operation of the device shown in FIGS. 2 and 3 will now be described. When the line voltage is applied between the terminals T_2 and T_8, current flows through the normally closed contacts SS1 and Th between the terminals T_2 and T_6, whereby the motor M (FIG. 1) is energized to prepurge the system as previously described. At the same time, the capacitor C_5 (FIG. 3) is charged by the output voltage of the transformer Tr. The transistors Q_1, Q_3 and Q_6 are made conductive by the increase in the voltage across capacitor C_5. When the voltage across capacitor C_8 reaches a predetermined value at a predetermined time such as about 20 seconds, the transistor Q_5 turns ON, transistor Q_6 turns OFF, and the transistor Q_7 turns ON. When the transistor Q_7 is ON, the coil T_x of the relay is energized so that the normally open contact T'_x (FIG. 2) is closed. This corresponds to the closing of the contact TS1 of FIG. 1. Thus, when the terminal T_6 is positive, the current flows through the diode D_5 and charges the main capacitor C_1, and accumulates magnetic energy in the ignition transformer IG (FIG. 1). When the terminal T_2 is positive, the voltage applied to the gate of the thyristor S reaches a predetermined value, whereupon the thyristor S is made conductive, so that the charge stored in the main capacitor C_1 is discharged through the thyristor S, terminal T_2, ignition transformer IG and terminal T_1. Therefore, both the electric energy accumulated at the main capacitor C_1 and the magnetic energy accumulated at the transformer IG are discharged by spark plug P.

The coil R_2 of the relay is energized by the current flowing through the heater resistor SSH of the safety switch, diode D_3, and normally open contacts R'_1-a. Thus, the normally open contact R'_2 is closed, the fuel solenoid V (FIG. 1) is energized, the fuel valve is opened, and the fuel supply is started. As previously described, the spark discharge occurs at the spark plug P, and accordingly the fuel is ignited. As a result of the growth of the flame, flame detector F (FIG. 1) detects the flame, and if the resistance of the detector is reduced, the transistor Q_1 having a base connected to the flame detector F through the terminal T_3 turns OFF, and accordingly the transistor Q_2 turns ON. Thus, the coil R_1 of the relay is energized by the current flowing through the transistor Q_2, and the contact R'_1 is switched to the contact *b* so that the heater resistor SSH of the safety switch is cut out. At the same time, the transistor Q_3 turns OFF so that capacitor C_7 starts to change with the current flowing through the resistor r_{12}. As the capacitor C_7 is charged, the voltage across the capacitor C_7 reaches a predetermined value after a predetermined time such as 15 seconds, and the transistor Q_4 turns ON. Thus, the charge stored in the capacitor C_8 is discharged through the transistor Q_4, with the result that the transistor Q_5 turns OFF, while the transistor Q_6 turns ON, the transistor Q_7 turns OFF, and the coil T_x of the relay is deenergized. Thus, the contact T'_x is opened, and the function of the ignition system including the thyristor S is stopped. Thereafter the burner device is operated by the normal combustion process.

After the fuel supply and the spark discharge are started, if sufficient growth of the flame is not obtained in a predetermined time, the flame detector F does not

operate, and accordingly the coil R_1 is not energized so that the connecting point R'_1 is not switched. Accordingly, the energization of the safety switch to the heater resistor SSH is continued. If the energization of SSH exceeds a predetermined time limit, the safety switch is operated, the normally closed contact SS1 is opened, and the normally open contact SS2 is closed. Thus, as described in FIG. 1, the warning device A is operated at the same time the other functions of the system are all stopped. Then, before the start of the device, if the flame detector F is operated, the transistor Q_2 turns ON by the application of the line voltage to the terminals T_2 and T_8, the coil R_1 is energized, and the contact R'_1 is switched to the contact *b*. By selecting a suitable value for the resistor r_4 (FIG. 3), the current supplied to the coil R_2 through the resistor r_4 is insufficient to close the normally open contact R'_2, but is sufficient to hold the closed contact R'_2 in closed state. The fuel valve is not opened.

The other functions are the same as those in the embodiment shown in FIG. 1.

FIG. 4 shows the structure of the safety switch for use in the combustion control device of this invention. As shown in FIG. 4*a*, the safety switch SS comprises a housing 1, a bottom plate 2, a microswitch 3 contained therein, and switch operating mechanism. The microswitch 3 is conventional and is opened and closed through a push-button 4. The operating mechanism has a bracket 6 fixed onto the bottom plate 2 by a proper means, and tab-portions 6*a*, 6*b* and 6*c* are bent at right angles integral with the bracket 6. An operating arm 7 is provided at the tab portion 6*a* through a U shape leaf spring 8. The one end of the arm 7 is secured to the spring 8 by a proper means such as rivets through end 7*a* which is bent at a right angle. The other end of the arm 7 forms a substantially Z shape to project out of the housing 1 through the hole 10. At right angles to the arm 7 is a bimetal piece 9 attached at end 9*a*. The portion between 9*b*–9*c* at the free end of the bimetal piece 9 is bent as shown in the drawing to be substantially J in shape. Second leaf spring 10 is provided in the operating mechanism. The one end 10*a* of the spring 10 is secured to the second tab portion 6*b* of the bracket 6 by means such as rivets, and the other end 10*b* of the spring 10 is bent generally in a Z shape. The spring 10 is normally engaged with the end 9*c* of the bimetal 9 at the end 10*b*, that is, the end 10*b* is pushed up from the bottom to be biased as shown in FIG. 4*a*. Another leaf spring 5 is fixed to the microswitch 1 at one end between the spring 10 and the pushbutton 4 so that the free end of the spring 5 is always engaged with the bottom surface of the spring 10. The tab portion 6*c* of the bracket 6 is a stopper for restricting the movement of the spring 5. The heater resistor 12 (corresponding to SSH in FIG. 1) of the safety switch is surrounded by the U shape portion near the end of the bimetal piece 9. The end of a screw 11 passes through the hole (not shown) provided at the tab portion 6*a* of the bracket 6 and both legs of the spring 8 are screwed into the bent portion 7*a* of the spring 7.

Then, the operation of the safety switch thus constructed will now be described. At first shown in FIG. 4*a*, the end 10*b* of the spring 10 is engaged with the end 9*c* of the bimetal 9, and when the free end of the spring 5 and the push-button 4 is raised, the normal contact of the microswitch 3 is closed, while the back-contact is open. It is assumed that the bimetal 9 is strained in the direction that the bending of the ends 9*b*–9*c* is increased as the temperature rises. The current flows through the heater resistor 12, and as the resistor 12 generates heat, the temperature of the bimetal 9 is increased so that the end 9*c* is moved gradually to the right in FIG. 4*a*. At a predetermined temperature, the end 9*c* is disengaged from the end 10*b* of the spring 10. Thus, the end 10*b* of the spring 10 is lowered as shown in FIG. 4*b*, and pushes down the push-button 4 through the spring 5. As a result, the normal contact of the microswitch is opened, while the back-contact is closed. Simultaneously, the end 10*b* of the spring 10 is engaged with the side end of the bimetal 9 to hold the relation shown in FIG. 4*b*. Therefore, when the current to the heater resistor is cut off so that the temperature of the bimetal 9 is lowered, even if the lower end 9*b*–9*c* of the bimetal is returned to the state shown in FIG. 4*a*, the springs 10, 5 and push-button 4 do not return to the state shown in FIG. 4*a*. That is, the microswitch 3 is held in the state that the normal contact is open, that is, it is locked.

After the end 9*b*–9*c* of the bimetal 9 is returned to the state shown in FIG. 4*a*, and after the end 7*b* of the arm 7 is pushed down manually, the mechanism is reset when released by the springs 8 and 5. The end 9*c* of the bimetal 9 engages the bottom side of the end 10*b* of the spring 10, and further pushes up the end 10*b* to return to the state shown in FIG. 4*a*. Thus, the spring 5 and the push-button 4 return to the original state, so that the microswitch 3 is reset.

The end 7*a* moves leftwardly or rightwardly in FIG. 4*a* by rotating the screw 11 and the gap *g* between the legs may be varied. Thereby, the bimetal piece 9 integral with the arm 7 moves leftwardly or rightwardly as a whole, and accordingly the end 9*c* of the bimetal piece 9 moves relative to the end 10*b* of the spring 10 so that the amount of engagement varies. As the temperature of the bimetal piece 9 rises, the strain amount of the end 9*b*–9*c* of the bimetal piece 9 required for disengaging the end 9*c* also varies. This means that the time limit of the safety switch which disengages end 9*c* also varies. In other words, by the rotation of the screw 11, the predetermined time limit of the operation of the switch SS is easily adjusted. In addition, in operation, since it has no mechanical sliding portions, the set conditions do not become improper thus making the switch reliable and lockable.

Further, when trouble occurs in the device of this invention, it always fails safe. For example, before the combustion device starts, if the flame detector F senses a light, that is, the resistance is in fact zero, and the main switch (not shown) is thrown in, and the line voltage is applied between the terminal T_2 and T_6, the contact R''_1 is opened by the energization of the coil R_1 of the first electromagnetic relay, and accordingly the contact TS1 of the thermal switch is not closed. Therefore, the operation of the fuel valve and the operation of the ignition circuit do not occur. If the breakage of line takes place at the heater resistor SSH of the safety switch before it moves to the normal combustion state, the coil R_2 of the second electromagnetic relay is not energized or deenergized. Thus, the solenoid V for controlling the fuel supply means is not energized.

While the invention has been particularly shown and described with reference to the preferred embodiment thereof, it will be understood by those skilled in the art that various changes in form and details may be made

therein without departing from the spirit and scope of the invention.

I claim:

1. A device for controlling the ignition and combustion of a burner said device comprising

a. spark gas means for providing a spark to ignite said burner;

b. ignition transformer means for coupling energy to said spark gap means;

c. main capacitor means for discharging energy stored therein through said ignition transformer means;

d. normally non-conducting thyristor means connected in series with said main capacitor means and said ignition transformer means to form an ignition circuit for providing the discharge path of said main capacitor means through said ignition transformer means;

e. first timer means connected in series with said main capacitor means for completing said ignition circuit and rendering said thyristor means conducting after a first predetermined time period;

f. flame detector means responsive to a predetermined post-ignition burner flame for interrupting said ignition circuit and rendering said thyristor means non-conducting; and

g. safety switch means connected in series with said flame detector means and said first timer means for timing a second predetermined time period after said first predetermined time period and turning off said burner after said second predetermined time period, wherein said flame detector means prevents said safety switch means from completing said second time period upon the detection of a flame whereby said safety switch means turns off said burner only when said burner is in an operating state and no flame is detected.

2. The device as set forth in claim 1 further including means for purging said burner wherein said burner is prepurged at the beginning of said first predetermined time period.

3. The device as set forth in claim 1 wherein said safety switch means includes a heater and a heat sensitive switch wherein the detection of a flame by said flame detector means cuts the current through said heater thus preventing it from operating said heat sensitive switch.

4. The device as set forth in claim 1 wherein said first timer means includes a thermal switch comprising a heater and a normally open switch.

5. The device as set forth in claim 1 wherein said first timer means comprises

a. first Schmitt trigger means in series with said flame detector means;

b. relay means having a contact in series with said main capacitor means;

c. second Schmitt trigger means for energizing said relay means; and

d. timing capacitor means for switching said second Schmitt trigger means after said first predetermined time period, thus energizing said relay.

6. The device as set forth in claim 4 wherein said safety switch means comprises

a. a microswitch;

b. a first leaf spring for switching said microswitch;

c. a stationary bracket;

d. a U shaped leaf spring mounted on said bracket, the open end of said U being adjustable;

e. an arm mounted on one arm of said U shaped leaf spring; and

f. a J shaped bimetal piece mounted on said arm and positioned to hold said first leaf spring in a position wherein said microswitch is in a first state whereby upon the heating of said bimetal piece to a predetermined level, said bimetal piece moves to a position to release said first leaf spring thus switching said microswitch to a second state, wherein the time required to reach said predetermined level is said second time period.

7. The device as set forth in claim 6 said safety switch means further including means for adjusting the opening of said U shaped leaf spring wherein the adjustment of said opening causes a corresponding adjustment in said predetermined temperature level and thus said second predetermined time period.

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